BIOASSESSMENT AND PHYSICAL/CHEMICAL CHARACTERIZATION OF WALNUT CREEK AND WOMAN CREEK

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

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EXECUTIVE SUMMARY

A bioassessment and an analysis of the physical and chemical characteristics of Walnut and Woman Creeks within the boundaries of the Rocky Flats Environmental Technology Site (RFETS) was conducted to compare the overall ecologic health of Walnut Creek between Pond A-4 and Indiana Street to an analogous reach of Woman Creek. The study quantified biological, chemical, and physical characteristics of the two streams and evaluated the potential causes of variations in the aquatic communities along these creeks. The study also evaluated whether un-ionized ammonia discharges from the RFETS wastewater treatment plant could be impacting aquatic life in the receiving ponds or in the segment of Walnut Creek below the ponds. These stream reaches are currently designated as Segments 4 and 5 of Big Dry Creek (South Platte River Basin), and are classified for Aquatic Life Warm 2 as well as other uses. The work plan for this study was reviewed by personnel from the U.S. Environmental Protection Agency (EPA) Region 8, and the Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division.

For this study, the methods and procedures for conducting a Rapid Bioassessment Protocol III (RBP III) for stream impairment assessment in *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA 1989) were followed to the extent possible. The RBP III was modified in several respects, including: (1) adjustment of the scoring criteria for two of the habitat parameters included in the Habitat Assessment Field Data Sheet (EPA 1989), and (2) modification of the metrics describing the macroinvertebrate community to account for limited data at several sampling sites. The need to modify the bioassessment protocols is recognized in the EPA guidance, which was developed for relatively large perennial streams with characteristics different from the subject creeks in the study. Modifications to the RBP III to account for the intermittent nature of small western streams have been previously acknowledged to be reasonable and appropriate by EPA personnel and other experts in the field.

Review of historic water quality data revealed that the water quality within Walnut Creek below Pond A-4 generally complies with imposed water quality standards for Segments 4 and 5, including un-ionized ammonia, and is similar to water quality in Woman Creek. The limited data available from stream channel locations indicates that water quality parameters such as dissolved oxygen (DO), temperature, and pH are similar in magnitude in Walnut Creek and Woman Creek and are within ranges which can support aquatic life. As expected, aquatic life was found at all study locations that had water.

The study found that the macroinvertebrate community in Walnut Creek downstream of the A- and B-series ponds and upstream of Indiana Street is not as diverse or robust as that in Woman Creek above the Mower Diversion. Recent observations indicate that there is no macroinvertebrate community in this segment of Walnut Creek, except for the very downstream reach (approximately the last 500 feet upstream of Indiana Street), or in Woman Creek below the Mower Ditch, due to the lack of consistent flow. Fish species were not found in Walnut Creek below Pond A-4, due to a lack of flow. Only a single minnow species was found in any of the ponds tributary to lower Walnut Creek or in the pond at Walnut Creek and Indiana Street.

The study also found that the habitat of Walnut Creek below the A- and B-series ponds is of lower quality than that of Woman Creek, and large differences exist in substrate, the presence of habitat types, and the diversity and productivity of the riparian zone. These habitat differences are persistent, and would not change significantly with a change in flow regime.

An analysis of water chemistry and benthic sampling data indicate that the macroinvertebrate community in Walnut Creek below Pond A-4, and continuing downstream to the confluence with Big Dry Creek, is not adversely affected by ammonia concentrations during periods of release from Pond A-4. The intermittent flow regime in the current Segment 4 of Walnut Creek lessens the potential for effects in this reach, since little or no macroinvertebrate community exists without water.

Data also indicate that the characteristics of aquatic life in the pond in Walnut Creek at Indiana Street are generally similar to those in the A- and B-series ponds directly affected by wastewater discharges (Ponds B-3, B-4, B-5, and A-4), even though these upper ponds have experienced much higher un-ionized ammonia concentrations. While the biological health of the pond in Walnut Creek at Indiana Street is primarily limited by flow considerations, the biological health of the A- and B-series ponds is impaired by operational practices and stratification phenomena. Large water fluctuations in these ponds impair the development of stable habitat, and previous water quality investigations have documented that these ponds experience wide swings in pH and significant oxygen depletion at depth during seasonal periods of stratification. These factors likely prevent a greater abundance or diversity of fish species.

Since aquatic life exists in reaches of Walnut Creek between Pond A-4 and Indiana Street where there is water, and aquatic life could be sustained in the reach with increased flow conditions, the study concludes that the current aquatic life classification for this reach is appropriate. The report also concludes that there are significant biological and physical differences between this reach and the corresponding reach of Woman Creek.

The report further concludes that the lack of fish species and the current impairment of the macroinvertebrate community in Walnut Creek between Pond A-4 and Indiana Street is primarily caused by a lack of flow and by poor habitat conditions, which would not improve to the level observed in Woman Creek even with increased flow. The study found no obvious correlations between un-ionized ammonia concentrations and calculated metrics. Furthermore, operational practices at the ponds result in frequent and severe fluctuations in water level and, combined with a seasonal and persistent depletion of oxygen, significantly limit the ability of these ponds to support fish life. For these reasons, existing ammonia concentrations are not considered a significant cause of impairment in the ponds or in the reach of Walnut Creek below the ponds.

CHAPTER 1
INTRODUCTION AND PURPOSE

This report was prepared for the Rocky Flats Environmental Technology Site (RFETS) and describes the results of a bioassessment and analysis of the physical and chemical characteristics of Walnut and Woman Creeks within the RFETS property boundary. These stream reaches have been designated by the Colorado Water Quality Control Commission (WQCC) as Segments 4 and 5 of Big Dry Creek (South Platte Basin) and are classified for Aquatic Life Warm 2 and other uses. The current segmentation and classifications are shown on Figure 1-1.

The main purpose of the study was to assess the overall ecologic health of Walnut Creek and to evaluate the potential causes of variations in the aquatic communities along the two creeks. A primary focus was on potential biological effects of effluent discharges of un-ionized ammonia from the RFETS wastewater treatment plant (WWTP) to the A- and B-series ponds and to downstream reaches of Walnut Creek. This study was conducted to provide supporting documentation for a U.S. Department of Energy (DOE) proposal to the WQCC to resegment portions of Segments 4 and 5, such that all of Walnut Creek west of Indiana Street would become Segment 5, and to remove the ammonia standard from this revised Segment 5. Proposed resegmentation is shown in Figure 1-2.

The study does not address potential changes to the existing use classifications in these segments. Federal and state water quality regulations require proposals for changes in use classification to document the factors affecting the attainment of aquatic life uses or other beneficial uses, which may include physical, chemical, biological, and economic factors (40 CFR 131.3; 5 CCR 1002-8, Section 3.1.5). In general, this is accomplished by preparing a formal Use Attainability Analysis (UAA). Since the intent of this study was to evaluate a proposed resegmentation and potential elimination of the ammonia standard rather than a proposed reclassification, a formal UAA was not conducted.

Resegmentation requires a demonstration that the stream segment being proposed for resegmentation has different characteristics than the segment in which it is currently included in terms of flow, water quality, habitat, and biological conditions. Based on Section 3.1.6(4) of the state's Basic Standards For Surface Water, "segments shall generally be delineated according to the points at which the use, physical characteristics, or water quality characteristics of a water course are determined to change significantly . . . ." Furthermore, the assignment of standards is based on the nature of the pollutant, the need for standards, effects on organisms, and other factors as described in Section 3.1.7(2) of the Basic Standards For Surface Water.

Determination of flow and water quality characteristics of lower Walnut Creek below the RFETS ponds (proposed for resegmentation) and comparison of this data to similar data for Woman Creek (the comparison reach) relied on existing validated data generated by various environmental monitoring programs at RFETS. The bioassessment conducted for this study relied on data from a 1991 biological characterization study and new data generated in July and September 1994 which used procedures consistent with EPA's *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA 1989). The term bioassessment refers to the sampling of fish and benthic organisms from a stream or river. These procedures are premised on the fact that aquatic communities, and particularly macroinvertebrates, integrate the effects of physical and chemical characteristics of a stream reach thereby providing an evaluation of the overall ecological integrity of the stream. Macroinvertebrate communities are good indicators of localized conditions because they are relatively sedentary communities. Sampling of fish communities is also a part of EPA's protocols, although fish communities tend to reflect larger scale habitat and water quality phenomenon than do macroinvertebrates.

Bioassessment procedures rely on a comparison of habitat conditions (e.g., channel and substrate characteristics and flow regime) and descriptors of the aquatic community present at a particular study site to those of a defined reference station or reach. The reference station or reach is selected to represent the best available water chemistry, habitat, and biology for similar ecologic and hydrologic conditions. For purposes of hydrologic and water quality characterization, Woman Creek was selected as a comparable reach because of its hydrologic similarities to Walnut Creek, its current designation as part of Segment 4, and because it is relatively unaffected by operations at RFETS. For similar reasons, a location in upper Woman Creek was selected as a reference station for bioassessment purposes. The scope of this study included the following specific elements:

1. Review of existing data on physical, chemical, and biological characteristics of the study stream reaches.

2. Collection and analysis of additional water quality, habitat, and biological data using EPA's RBP Level III.

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3. Data analysis to compare the ecological integrity of the existing Segments 4 and 5 and downstream Segment 1.

4. Where the aquatic community was impaired relative to the reference station, evaluation of the physical/chemical cause or causes of impairment.

This report includes three chapters and two appendices, including the Introduction and Purpose. Chapter 2 describes the bioassessment study methods and the data collection efforts conducted in the summer and fall of 1994 that were designed to support the study. In Chapter 3, the habitat, biological, and water quality data are evaluated, and comparisons between Walnut Creek and the reference station in Woman Creek are made. In addition, a quantitative analysis of biological data is performed through calculated metrics that describe the biologic community and offer insight into the factors contributing to use impairment. A biological condition score which represents a composite of these metrics relative to the reference station was determined and used to assess the level of existing impairment, if any. In addition, several metrics were calculated for the results of fish sampling. Chapter 3 also presents conclusions and overall implications of the study results.

Appendix A describes the physical and flow characteristics of specific watersheds and stream segments of interest, including the reference reach, and presents historical flow data. Appendix B describes water quality characteristics of Walnut Creek and Woman Creek, presents historical and recently collected water quality data for both streams and ponds within the segments of interest, and discusses un-ionized ammonia results. Technical reviewers are encouraged to review Appendices A and B prior to reviewing the results of the bioassessment in Chapter 3 since the bioassessment results and report conclusions contained in Chapter 3 rely on data presented in the appendices.

REFERENCES

State of Colorado Water Quality Control Commission. 1993. *The Basic Standards and Methodologies for Surface Water*, 3.1.0, 5 CCR 1002-8.

U.S. Environmental Protection Agency. 1989. *Rapid Bioassessment Protocols for Use in Streams and Rivers - Benthic Macroinvertebrates and Fish.* EPA/440/4-89/001.

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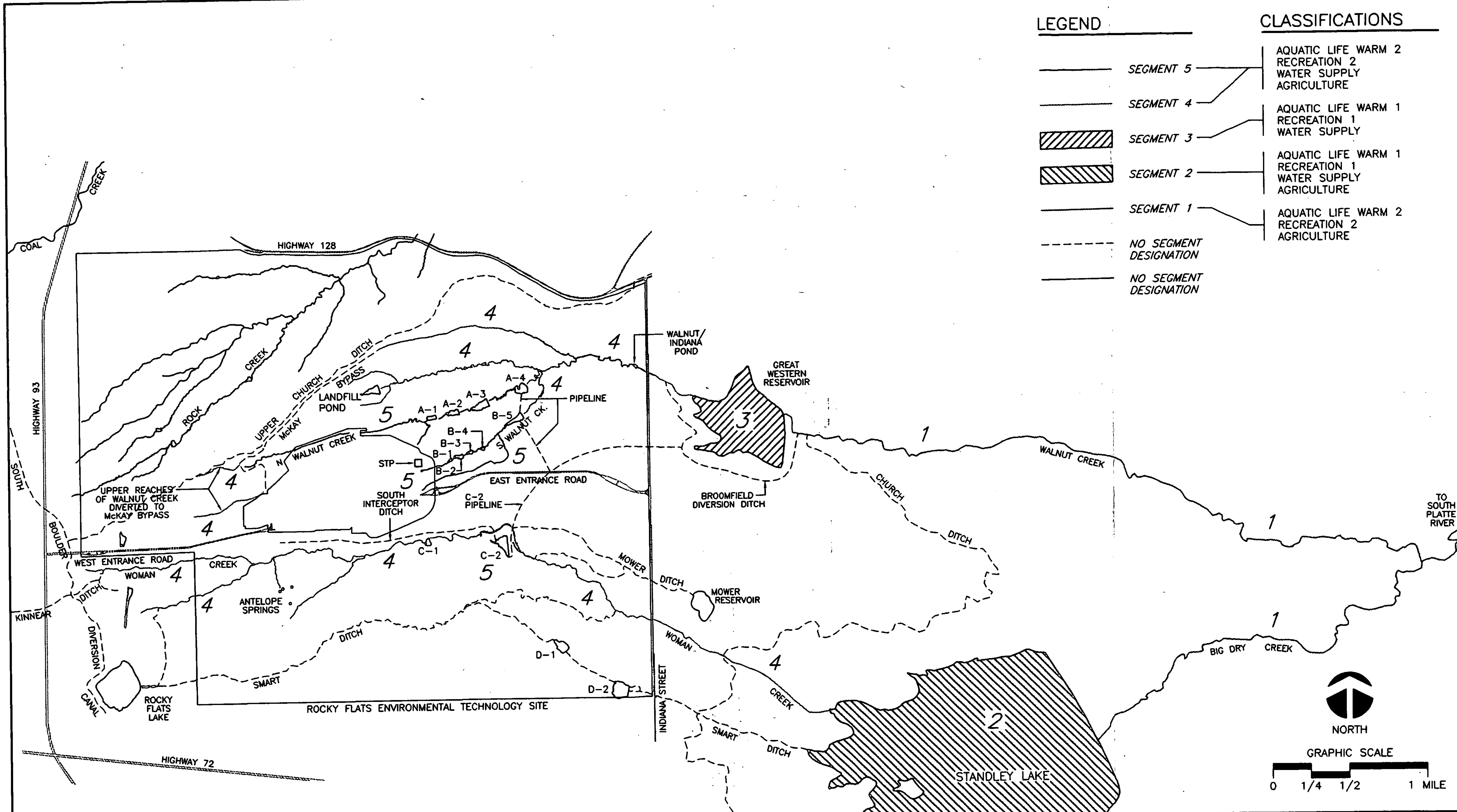

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DESIGN BY	EWM	CHECKED	EWM
DRAWN BY	KAL	APPROVED	-
DATE	FEB. 21, 1995	SCALE	1"=3200'

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FIGURE 1-1
EXISTING STREAM SEGMENTS AND CLASSIFICATIONS

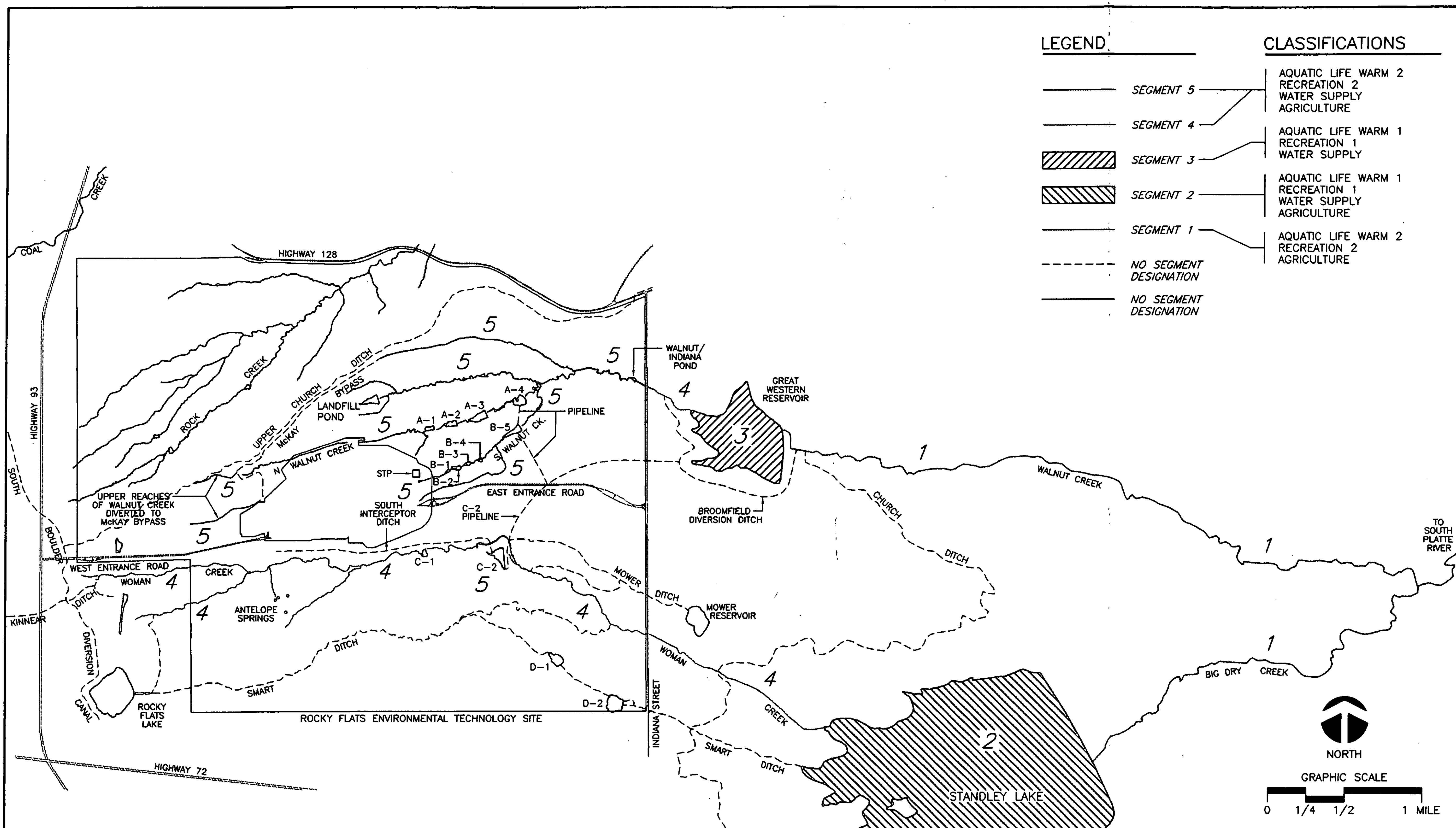

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FIGURE 1-2
PROPOSED STREAM SEGMENTS AND CLASSIFICATIONS

CHAPTER 2
BIOASSESSMENT STUDY METHODS

For the purpose of this study, the methods and procedures for conducting a RBP III for stream impairment assessment in *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA 1989) were followed to the extent possible. Data collected on fish communities were inadequate to enable complete application of the Rapid Bioassessment Protocols for fish (RBP IV or V). However, existing data on fish communities were integrated into the study to the extent possible.

The RBP III entails collection and analysis of three sources of data to evaluate changes in the aquatic community and possible sources of impairment: (1) information on physical habitat conditions of the creek, (2) water quality data, and (3) quantitative data on aquatic communities (macroinvertebrates, in the case of this study). For the RBP III, macroinvertebrates collected in the field are identified in the laboratory to the lowest possible taxonomic unit. Conditions at sampling sites are compared to one or more "reference sites" which represent the least disturbed condition in terms of chemistry, habitat, and biological condition. An empirical relationship is established between habitat quality and macroinvertebrate communities; then it is determined whether water quality conditions are causing impairment.

The RBP III was modified in several respects for use in this study. The main modifications included: (1) adjustment of the scoring criteria for two of the habitat parameters included in the Habitat Assessment Field Data Sheet (EPA 1989), and (2) modification of the metrics describing the macroinvertebrate community to account for limited data at several sampling sites. These modifications are described in more detail in Section 2.2 of this chapter and were made because the RBP III was developed for relatively large, perennial streams with characteristics different from the subject creeks in the study. It does not include procedures for modifying the analysis to account for small intermittent or ephemeral streams, streams influenced by ponds, or streams heavily influenced by anthropogenic activities, all of which occur at RFETS.

2.1 SELECTION OF SAMPLING STATIONS

The RBP III requires the collection of macroinvertebrate samples and rating of corresponding habitat conditions. Sampling stations for this study were selected to coincide with sites used for past and ongoing flow and water quality sampling, to determine the influence of RFETS operations on the aquatic community and habitat, and to provide a reasonable representation of the study creek segments. The *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA 1989) call for sampling of primarily riffle/run macroinvertebrate communities since these are typically the most productive habitat. Figure 2-1 shows the locations of the 1994 habitat assessment and biological (e.g., macroinvertebrate and fish) and water quality sampling sites. Macroinvertebrate and water quality sampling conducted on Woman Creek in 1991 as part of the *Baseline Biological Characterization of the Terrestrial and Aquatic Habitats at the Rocky Flats Plant* (EG&G 1992) were also used in the bioassessment. Sampling stations from the 1991 study that were relevant to this study are also shown on Figure 2-1. These stations are located in the current Segments 4 and 5 and include pond and creek sites.

2.2 HABITAT ASSESSMENT

The key to the RBP III is the completion of a habitat assessment (HA) at each of the sampling sites where macroinvertebrates are collected. A HA entails inspecting the sampling site and rating habitat quality in terms of three principal categories: (1) bottom substrate, flow, and cover; (2) channel morphology characteristics; and (3) the degree of channel alteration including bottom scouring and deposition. The parameters related to bottom substrate, flow, and cover conditions receive the most weight in the HA, followed by channel morphology characteristics, then channel alteration parameters. A sample field habitat assessment sheet from the EPA guidance (EPA 1989) is included as Table 2-1 .

Two of the parameters were modified to increase the sensitivity of the HA to account for the intermittent nature of the study creeks. The two parameters modified were: (1) the flow criteria and (2) pool/riffle, run/bend ratio. The modifications to these parameters are described in Table 2-2. The HA was completed in November 1994 and January 1995 at a total of 20 sampling sites which included both the 1991 Woman Creek and 1994 Walnut Creek macroinvertebrate sampling sites (Figure 2-1).

2.3 BIOLOGICAL DATA

Biological data is available through a past sampling effort related to RFETS sitewide characterization activities, and from sampling efforts conducted in July and September 1994 by EG&G personnel. In addition, regional fish data for the reach of Walnut Creek below Great

Western Reservoir is available through the Colorado Division of Wildlife. These data sources are summarized below.

All RFETS biological sampling conducted to support this study was performed in accordance with the latest *Rocky Flats Ecology Standard Operating Procedures* 4-K49-ENV-ECOL.02 in Manual 5-21200-OPS-EE.

2.3.1 Baseline Biological Characterization of the Terrestrial and Aquatic Habitats at RFETS

In the spring and fall of 1991, aquatic water quality and biological samples were collected at 28 stream locations and 17 ponds in and around RFETS to support the *Baseline Biological Characterization* report (EG&G 1992). This report was designed to provide benchmark data on the aquatic environment at RFETS. As part of the study, baseline aquatic surveys were conducted in the spring and fall of 1991 to document the occurrence and relative abundance of species. Spring surveys consisted solely of aquatic benthic macroinvertebrate sampling in the Woman Creek drainage, while the fall surveys consisted of fish, plankton, algae, macrophytes, and benthic and water column invertebrates sampling in both Woman and Walnut Creek drainages (EG&G 1992).

On the Walnut Creek drainage, samples were collected at the four A-series ponds on North Walnut Creek, the five B-series ponds on South Walnut Creek, the small flow-through pond at Walnut and Indiana, and one stream station located approximately 1,000 feet upstream of this pond. These locations are shown on Figure 2-1. On Woman Creek, samples were collected at four stream locations upstream of Pond C-1 (in the central portion of the drainage), at Pond C-1, and at four stream locations downstream of Pond C-1. These methods are compatible with those in the RBP III. Surber samples were used and macroinvertebrates identified to the lowest taxa possible. Eight of the locations were along the main stems of the creeks and were used in this study.

This data set is significant in that it represents the majority of aquatic organism data available for Woman Creek. Raw data generated as part of the baseline study were obtained in order to make quantitative comparisons between Woman and Walnut Creeks. The results of the quantitative analysis is presented in Chapter 3.

2.3.2 Qualitative and Quantitative Macroinvertebrate Stream Sampling - 1994

A total of 21 samples were taken on July 26, 1994 from six stream sampling stations:

- Walnut Creek, west of Indiana (D1) (only during release of Pond A-4);
- Walnut Creek east of Great Western Reservoir and below the Church Ditch outfall (D2) (which was dry at this time);
- Walnut Creek at Old Wadsworth (W1);
- Walnut Creek just above the confluence with Big Dry Creek (W2); and
- Big Dry Creek just below and just upstream of the confluence with Walnut Creek (BD1 and BB2).

Hand picking, D-frame net, and seine net samples were taken. Benthic samples could not be collected from Walnut Creek between the ponds and Indiana Street as this reach was dry during the sampling period. Quantitative Surber samples were also taken from each of the six stream sites on September 6, 1994. Three replicate Surber samples were taken from riffle habitats at each site and the replicates were composited by the field crew before shipment for laboratory analysis.

2.3.3 Drift Net Sampling During Pond Release in 1994

Macroinvertebrate drift and water chemistry were sampled before and during release of RFETS water from Pond A-4 to evaluate the effect of this water on downstream biota in Walnut and Big Dry Creeks. Between September 6 and 13, 1994, four replicate drift nets were placed at each site for a 24-hour period prior to the effluent release and following effluent reaching each site. In total, 33 drift net samples were collected. The drift data are semi-quantitative since data are not normalized to known flow through the nets but are reported as number of organisms captured in 24 hours (number/day). (Even with known depth of water, the cross-sectional area of the net opening, and an estimate of current velocity, clogging of the nets over time often prohibits quantification of the amount of water actually filtered by each net.)

2.3.4 Quantitative Macroinvertebrate Sampling from Segment 5 Ponds Associated with the Operable Unit 6 Ecological Risk Assessment - 1994

Quantitative samples of aquatic biota were collected in June 1994 primarily to support the ecological risk assessment for Operable Unit (OU) 6. These data, however, can also be used to characterize the Segment 5 pond ecosystems. At each pond (A1, A2, A3, A4, B1, B2, B3, B4, B5, D1, D2, and Lindsay Pond), five multi-cores, emergent insect traps, integrated water column zooplankton samples, and surface (0.25m depth) phytoplankton samples were collected to quantify benthic community composition, aquatic insect production, zooplankton, and phytoplankton community composition.

2.3.5 Collection of Water Quality Data - 1994

Field measurements of pH and temperature, and laboratory analyses for ammonia, major cations and anions, and metals, were collected concurrently with the July and September macroinvertebrate sampling at a number of stations along Walnut Creek as indicated on Figure 2-1. The purpose of the sample collection was to examine in more detail the water quality both prior to and during a release of water from RFETS.

To assess the fate of ammonia discharged from the WWTP, EG&G collected additional samples at three locations on Walnut Creek. Between March and September 1994, ammonia, pH, and temperature were monitored in the effluent from Pond A-4 and at two downstream locations: the confluence of Walnut Creek with the end of the Broomfield Diversion Ditch just east of Great Western Reservoir, and at Old Wadsworth Street (Stations D2 and W1 on Figure 2-1). Samples were collected approximately every two days during discharges from Pond A-4.

2.3.6 Evaluation of Macroinvertebrate Data

Quantitative biological data on macroinvertebrates in the creeks were evaluated using procedures described in EPA's RBP III. The RBP III relies on eight metrics which are used to assess the characteristics of the macroinvertebrate community at the sampling and reference sites. Each metric assesses a different aspect of the macroinvertebrate community structure and composition. The eight EPA metrics are as follows: (1) taxa richness; (2) family biotic index, in this instance the Hilsenhoff Biotic Index (HBI); (3) ratio of scrapers to filtering collectors; (4) ratio of

Ephemeroptera, Plecoptera, and Trichoptera (EPT) to Chironomidae abundances; (5) percent contribution of dominant taxon; (6) EPT index; (7) community loss index; and (8) ratio of shredders to the total benthic community. The eighth metric could not be calculated for this study because coarse particulate organic matter (CPOM) samples were not collected, and calculation of this metric relies on CPOM data. The remaining seven calculated metrics were combined to provide an overall biological condition score using guidance in EPA's *Rapid Bioassessment Protocols* document. This biological condition score is an integrated measure of the health of the benthic community relative to the reference station and is used to determine the presence of any impairment.

The taxa richness is the number of genera and/or species present at a sampling location. It is a reflection of the overall health of the aquatic community at the sampling site. Healthy communities usually have more species and a higher taxa richness than impaired ones.

The HBI integrates the abundance of pollution tolerant species with the abundance of all taxa in the community. The higher the HBI, the more pollution-tolerant the community. Tolerance values for taxa were based on Hilsonhoff (1987), Rosenberg and Resh (1993), and professional judgement. Some taxa were not included in the HBI calculation because sufficient identification was not possible. However, in all cases, the unidentified taxa were only a small portion of the total community.

Macroinvertebrates can be grouped according to their dominant food base or mechanism of food collection. Three important groups in riffle/run areas are scrapers, filtering-collectors, and shredders. The ratio of scrapers to filtering-collector feeding groups may indicate the relative abundance of a particular food source. A low ratio of scrapers to filtering collectors may indicate increased organic enrichment. However, filterers are also very intolerant to toxicants bound to fine particulate matter so this ratio may not be a good indicator of organic enrichment if toxics are present. Other metrics such as HBI or the EPT index may help to indicate organic enrichment if toxicants are also present.

The community balance is measured by the ratio of EPT to Chironomidae. Species from the family Chironomidae (midges) are more tolerant to pollution, particularly metals, than are the EPT taxa. Healthy communities tend to have a relatively even distribution among these four

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groups. An impaired community will tend to have a higher number of chironomids and, therefore, a lower ratio.

The percent contribution of the dominant taxon can indicate environmental stress. Stressed communities will often be dominated by relatively few taxa. Therefore, a high percentage may indicate pollution or some other environmental stress.

The EPT represents the total number of taxa within the three insect orders: Ephemeroptera, Plecoptera, and Trichoptera. Species in these insect orders are generally sensitive to water quality and habitat degradation; the higher the EPT index value, the less pollution or habitat degradation.

The community loss index compares the species composition of each sampling station to that of the reference station. This metric is an indicator of dissimilarity. Higher values indicate that many of the taxa present at the reference station are not present at the subject station and this may be due to impairment.

The ratio of shredders to the total number of individuals collected is also an indication of potential impairment because shredders are sensitive to riparian zone impacts from toxicants adsorbed to the CPOM that the shredders ingest. However, CPOM samples were not taken for this study, so the ratio of shredders to the total number of individuals could not be calculated.

2.3.7 Colorado Division of Wildlife Stream Survey

In the fall of 1992 and 1993, the Colorado Division of Wildlife performed a limited fish survey of Big Dry Creek, including four stations below the confluence with Walnut Creek. These fish data are combined with data collected as part of the *Baseline Biological Characterization* report and are presented in Table 2-3. Analysis of fish data is provided in Chapter 3.

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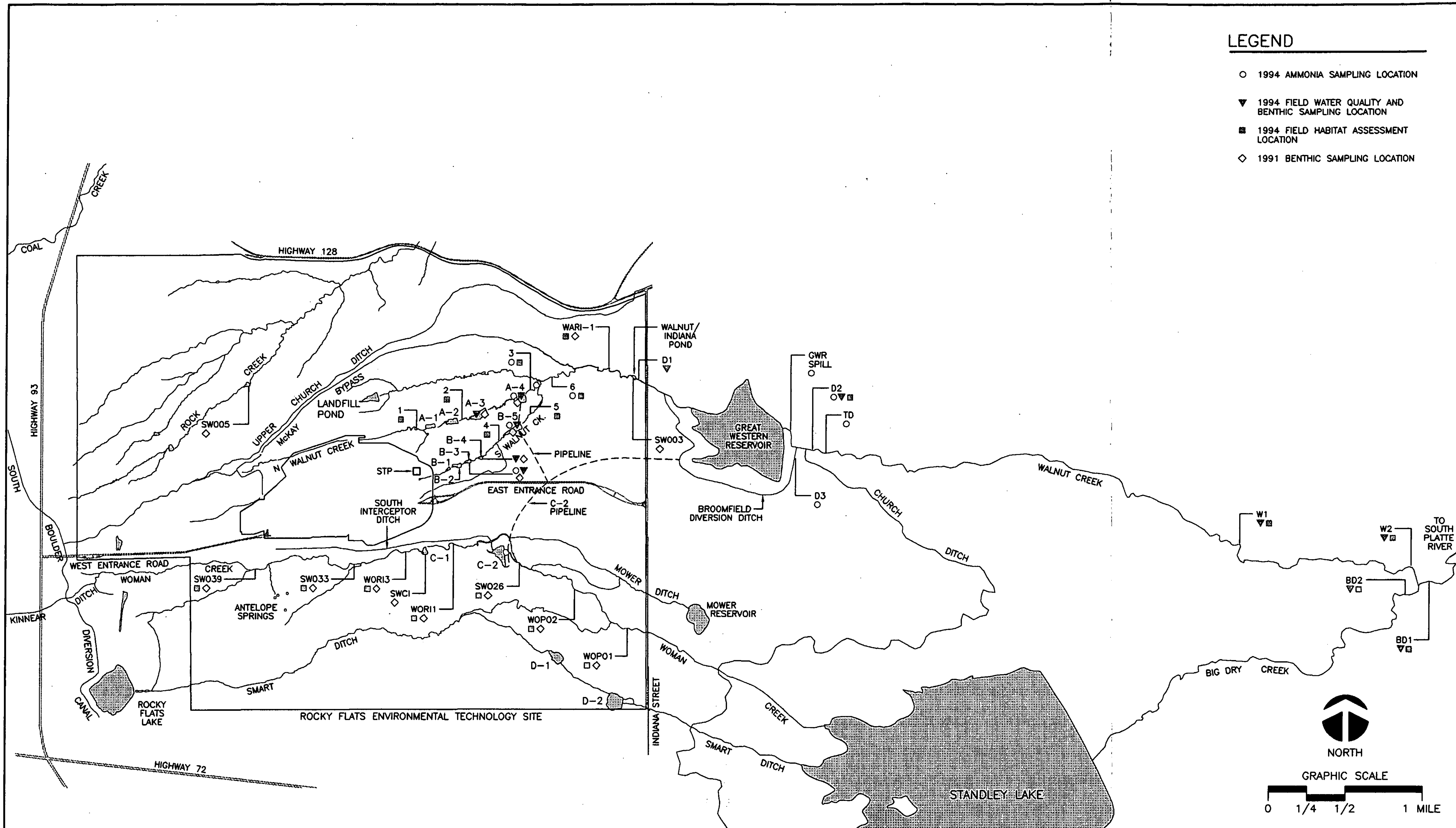

PROJ. NO.	901-004.330	DWG. NO.	-
DESIGN BY	EWM	CHECKED	EWM
DRAWN BY	KAL	APPROVED	-
DATE	FEB. 21, 1995	SCALE	1"=3200'

PREPARED FOR

U.S. DEPARTMENT OF ENERGY

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

FIGURE 2-1
BIOASSESSMENT SAMPLING STATIONS

TABLE 2-1
HABITAT ASSESSMENT FIELD DATA SHEET

HABITAT ASSESSMENT FIELD DATA SHEET

Habitat Parameter	Category: Excellent	Good	Fair	Poor
1. *Bottom substrate/ available cover[(a)]	Greater than 50% rubble, gravel, submerged logs, undercut banks, or other stable habitat. 16-20	30-50% rubble, gravel or other stable habitat. Adequate habitat. 11-15	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 6-10	Less than 10% rubble gravel or other stable habitat. Lack of habitat is obvious. 0-5
2. Embeddedness[(b)]	Gravel, cobble, and boulder particles are between 0 and 25 % surrounded by fine sediment 16-20	Gravel, cobble, and boulder particles are between 25 and 50 % surrounded by fine sediment 11-15	Gravel, cobble, and boulder particles are between 50 and 75 % surrounded by fine sediment 6-10	Gravel, cobble, and boulder particles are over 75 % surrounded by fine sediment 0-5
3. ≤0.15 cms (5cfs) → *Flow at rep. low flow[(a)]	Cold >0.05 cms (2 cfs) Warm >0.15 cms (5 cfs) 10-20	0.03-0.05 cms (1-2 cfs) 0.05-0.15 cms (2-5 cfs) 11-15	0.01-0.03 cms (.5-1 cfs) 0.03-0.05 cms (1-2 cfs) 6-10	<0.01 cms (.5 cfs) <0.03 cms (1 cfs) 0-5
or >0.15 cms (5cfs) → Velocity/depth	Slow (<0.3 m/s), deep (>0.5 m); slow, shallow (<0.5 m); fast (>0.3 m/s), deep; fast, shallow habitats all present. 16-20	Only 3 of the 4 habitat categories present (missing riffles or runs receive lower score than missing pools). 11-15	Only 2 of the 4 habitat categories present (missing riffles/runs receive lower score). 6-10	Dominated by one velocity/depth category (usually pool). 0-5
4. * Channel alteration[(a)]	Little or no enlargement of islands or point bars, and/or no channelization. 12-15	Some new increase in bar formation, mostly from coarse gravel; and/or some channelization present. 8-11	Moderate deposition of new gravel, coarse sand on old and new bars; pools partially filled w/silt; and/or embankments on both banks. 4-7	Heavy deposits of fine material, increased bar development; most pools filled w/silt; and/or extensive channelization. 0-3
5. Bottom scouring and deposition[(a)]	Less than 5% of the bottom affected by scouring and deposition. 12-15	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8-11	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 4-7	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 0-3

(a) From Ball 1982.
(b) From Platts et al. 1983.
Note: * = Habitat parameters not currently incorporated into BIOS.

TABLE 2-1
HABITAT ASSESSMENT FIELD DATA SHEET
(Page 2 of 2)

HABITAT ASSESSMENT FIELD DATA SHEET (cont.)

Habitat Parameter	Category: Excellent	Good	Fair	Poor
6. Pool/riffle, run/bend ratio[(a)] (distance between riffles divided by stream width)	5-7. Variety of habitat. Deep riffles and pools. 12-15	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8-11	15-25. Occassional riffle or bend. Bottom contours provide some habitat. 4-7	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 0-3
7. Bank stability[(a)]	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 9-10	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 6-8	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme high flow. 3-5	Unstable. Many eroded areas. Side slopes >60% common. "Raw" areas frequent along straight sections and bends. 0-2
8. Bank vegetative stability[(b)]	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 9-10	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 6-8	25-49% of the streambank surfaces covered by vegetation, gravel, or larger material. 3-5	Less than 25% of the streambank surfaces covered by vegetation, gravel, or larger material. 0-2
9. Streamside cover[(b)]	Dominant vegetation is shrub. 9-10	Dominant vegetation is of tree form. 6-8	Dominant vegetation is grass or forbes. 3-5	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 0-2
Column Totals	___	___	___	___

Score ________

TABLE 2-2
MODIFICATIONS TO HABITAT ASSESSMENT PARAMETERS FOR RFETS BIOASSESSMENT

Excellent	Good	Fair	Poor
Flow Category (Criteria #3)			
Flow > 0.3 cfs All of bottom channel covered. Four habitats are present (deep, fast, shallow, and slow). 16-20	Flow = 0.05-0.3 cfs All of channel covered. Only 3 of the 4 habitat types present. 11-15	Flow <0.05 cfs Intermittent section. Only 2 of the 4 habitat types present. 6-10	Flow = 0 May have wet channel bottom or some pools. 0-5
Pool/Riffle, Run/Bend Ratio (Criteria #6)			
Distinct riffles and pools exist, some pool depths >3". 12-15	Riffles and pools exist but they are not well defined. Pool depth <3". 8-11	Stream has flow but only one habitat type evident. Little habitat variability. 4-7	Dry or moist channel with no flow; soil and sediment accumulation. 0-3

TABLE 2-3
LIST OF SPECIES OF FISH COLLECTED IN WALNUT, WOMAN, AND BIG DRY CREEKS

	So. Walnut Creek[1] (in ponds)	Walnut Creek[1] (below ponds)	Pond at Indiana (SW03)[1]	SW01/SW02 Woman Creek[1]	Woman Creek[1]	Big Dry Creek[2] (below confluence with Walnut)	Big Dry Creek[2] (above confluence with Walnut)
No. of Stations	5	2	1	2	9	4	2
Classification	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2
Ammonia Standard	0.1 mg/L(ch)	0.1 mg/L(ch)	0.1 mg/L(ch)	0.1 mg/L(ch)	0.1 mg/L(ch)	none	none
Species							
Longnose Sucker							X
Creek Chub					X	X	X
Longnose Dace						X	X
White Sucker				X	X	X	X
Johnny Darter							X
Green Sunfish				X	X	X	X
Small Mouth Bass							X
Fathead Minnow	X	X	X	X	X	X	X
Large Mouth Bass				X	X		
Stoneroller					X		
Golden Shiner				X	X		
Total No. of Species	1	1	1	5	7	5	8

[1]Data from EG&G, 1992, *Baseline Biological Characterization of the Terrestrial and Aquatic Habitats at the Rocky Flats Plant.*
[2]Data from Limited Fish Survey Data from Colorado Division of Wildlife Stream Surveys (1992-1993, unpublished).

CHAPTER 3
RESULTS OF BIOASSESSMENT

This chapter presents the results of a bioassessment for Woman and Walnut Creeks using data discussed in Chapter 2 and evaluates the ecological integrity of the two creeks. Analyses of flow conditions and water quality are provided in Appendices A and B, respectively. The results of these analyses have been incorporated into this chapter.

3.1 BIOASSESSMENT

3.1.1 Habitat Assessment

Habitat quality plays a major role in determining the characteristics of the benthic and fish communities present. In particular, flow conditions, substrate type, water temperature, the presence of aquatic and riparian vegetation, and water quality are major factors (Ward and Kondratieff 1992). The habitat assessment procedure in *Rapid Bioassessment Protocols* was conducted at stations having biological data for Walnut and Woman Creeks to compare associated habitat quality. Since the number of biological stations on Walnut Creek was limited, a habitat assessment was also performed at six additional stations on Walnut Creek to enable a more complete comparison of habitat conditions with Woman Creek. The locations of the habitat assessment are shown on Figure 2-1. Modifications to the EPA habitat assessment procedure used to account for small, intermittent streams such as Woman and Walnut Creeks are described in Section 2.2.

Table 3-1 provides a description of the habitat conditions at each station; the results of the habitat parameter scores are summarized in Table 3-2. It should be noted that the station designations used in the previous macroinvertebrate sampling efforts were used for the habitat assessment locations. Locations of additional habitat assessments were assigned a new number in a downstream direction (Figure 2-1).

Habitat assessment scores for Walnut Creek between the A- and B-series ponds and Indiana Street versus Woman Creek are shown on Figure 3-1. This figure indicates that the scores for the Walnut Creek stations are generally less than for Woman Creek. The average score for the seven stations on Woman Creek is 112.0 which is significantly higher than the average score of 84.2 on Walnut Creek at the 95 percent level of confidence.

Table 3-2 shows that the habitat parameters with the lowest ratings on Walnut Creek include flow, pool/riffle, and stream-side cover. Walnut Creek below Ponds A-4 and B-5 to Indiana Street has long periods of no flow and the flow regime consists of intermittent, slug releases from Pond A-4. This compares to a nearly perennial flow regime along many reaches of Woman Creek. Since some periods of little or no baseflow do occur in these reaches along Woman Creek, they are referred to as having "sustained flow" rather than perennial or intermittent flow. (See Appendix A for a description of the flow regime in the two creeks.) Generally, a lack of flow will significantly affect fish and macroinvertebrate communities. Most fish and macroinvertebrates cannot withstand long periods of desiccation such as those that occur in Walnut Creek below the ponds. Increased water temperature and decreased dissolved oxygen levels from intermittent discharges also affect fish and macroinvertebrates.

Flow is not the only reason for the lower habitat ratings along Walnut Creek. Field investigation of the Walnut Creek channel below Ponds A-4 and B-5 reveals little variation in habitat types (e.g., pools, runs, and riffles) and the pools, runs, and riffles that do exist are poorly defined and barely distinguishable from other sections of the channel. While deep pools are also lacking along Woman Creek, habitat types are more varied and pronounced.

The nature of riparian vegetation is also very different between Walnut Creek below the A- and B-series ponds and Woman Creek. Riparian vegetation for this segment of Walnut Creek is dominated by grasses and forbs and lacks shrubs and trees. The riparian community along nearly the entire main stem of Woman Creek is multi-layered and includes grasses/forbs, shrubs, and trees.

The difference in habitat scores between Walnut Creek below the ponds versus Woman Creek appears to demonstrate a cumulative and direct cause and effect relationship. Woman Creek has a sustained flow regime in several large reaches with relatively well-defined habitat types within a diverse and productive riparian corridor. This riparian corridor provides shading, stable banks, and organic matter to the creek. The organic matter is an energy source for the macroinvertebrate community which, in turn, can support fish species. In contrast, Walnut Creek has an intermittent flow regime with little habitat variation and a sparse riparian area.

Since a lack of flow in the creek was particularly responsible for the relatively low habitat scores for the Segment 4 Walnut Creek stations and at stations WOP01 and WOP02 on Woman Creek (Figure 3-1), an analysis was conducted, as discussed in the EPA guidance document, to ascertain the effects of increased flow and other "reversible habitat alterations" on the habitat ratings. The following guidelines and assumptions were considered in this analysis:

1. There is a reasonable likelihood of flow improvements occurring in Walnut Creek below the ponds. Based on Pond A-4 discharge records, a continuous flow of approximately 0.15 cfs discharged to Walnut Creek below Pond A-4 and a reduced maximum release rate of approximately 1.86 cfs are achievable under a revised operational scenario.

2. There are no current plans to actively revegetate the riparian zone along lower Walnut Creek.

3. No water would be released directly from Pond B-5 under future operational scenarios.

4. There is a reasonable likelihood of reducing diversions in the Mower Ditch on Woman Creek in the near future such that there could be 0.05-0.5 cfs baseflow in Woman Creek downstream of this ditch during most times of the year; and

5. With increased flow in either creek, there could be changes in species composition and the vigor of riparian communities; however, no major shifts in dominant growth form (e.g., grasses to shrubs) would occur.

The results of the analysis of reversible habitat alterations are shown in Table 3-3 and Figure 3-2. This analysis found that, in general, there is a low potential for significant habitat improvements in the foreseeable future for either Walnut or Woman Creeks. Potential pond operational changes would result in increased flow in Walnut Creek below Pond A-4 which, in turn, would increase habitat scores slightly for several habitat parameters. A continuous flow in Walnut Creek below Pond A-4 would reduce the degree of imbeddedness and fine sediment in the channel bottom to a modest extent; however, it would not result in significant geomorphological changes to channel geometry, including pool/riffle characteristics. Likewise, reduced diversions in the Mower Ditch would improve habitat conditions a similar degree in lower Woman Creek.

As shown in Figure 3-2, habitat would still be of generally lower quality in Walnut Creek compared to Woman Creek, even with foreseeable improvements in reversible habitat alterations. This is because important parameters such as riparian vegetation characteristics, pool/riffle habitat, and substrate type would not be measurably improved in Walnut Creek by increased flow alone. With flow improvements to both creeks, the average habitat score for Woman Creek would be 116.6, which is still significantly higher than the average of 91.0 for Walnut Creek at the 95 percent level of confidence.

Figure 3-3 presents the results of a separate comparison of the habitat conditions in Walnut Creek below the ponds with those for channel segments between and above the ponds. This figure shows that creek habitat quality is generally similar both above and below the ponds, with the exception of Station 01 which is located above Pond A-1 on North Walnut Creek. Station 01 is representative of a relatively short reach of this creek (approximately 500 feet in length) above the A-series ponds. Habitat was rated high at this station due to the diverse riparian vegetation and perennial baseflow observed. Flow data at other locations indicate that baseflow is often zero and flow typically occurs only in response to storm events.

3.1.2 Bioassessment Results

3.1.2.1 Benthic Organisms

The purposes of the bioassessment were to:

- Evaluate differences in aquatic life in those portions of Walnut and Women Creeks located on the plant site;
- Assess the effects of habitat quality on aquatic life; and
- Assess the effects of water quality, particularly ammonia, on aquatic life in Walnut Creek.

Data collected by EG&G in May and June 1991 (see Chapter 2) and data collected in July 1994 were analyzed. The RBP III was conducted. This protocol is designed to enable assessment of impacts due to habitat and water quality. Modifications to the RBP III made in the study are described in Chapter 2. Each data set was analyzed separately and conclusions drawn based on the results.

Data on macroinvertebrates were collected by EG&G in May through June 1991 at several locations along Woman and Walnut Creeks. The sampling locations are shown on Figure 2-1. Habitat assessments were conducted at these stations in December 1994 and January 1995, and flow and water quality conditions preceding sampling and at the time of sampling were evaluated. Based on past flow data and pond operations, the flow regime of the two creeks has not changed significantly nor have any major storm events occurred since the dates of the macroinvertebrate sampling to significantly alter habitat conditions such as channel geometry, substrate type, occurrence of pools and riffles, or riparian vegetation characteristics. Therefore, present habitat conditions should be indicative of conditions present at the time of macroinvertebrate sample collections.

Station SW039 on Woman Creek was used as a reference station for the May and June 1991 data (Figure 2-1). This station is located in the headwaters of Woman Creek, is generally unimpacted by site activities, and represents the best available station in terms of water quality, habitat condition, and flow condition on Woman Creek. It is a reasonable reference site for Walnut Creek given the close proximity and similar characteristics of the creeks.

The metrics and biological condition scores calculated for the May and June 1991 data set are shown in Table 3-4. Figures 3-4A and 3-4B show the values of the metrics for the: (1) upstream Woman Creek stations with sustained flow; (2) Woman Creek stations downstream of the Mower diversion that had intermittent flow; and (3) Walnut Creek stations. It should be noted that the stations on Woman Creek referred to as having sustained flow have baseflow most of the year except for brief periods of no or very low baseflow.

As shown in Figures 3-4A and 3-4B, the stations on Woman Creek with sustained flow had the most diverse macroinvertebrates with the greatest number of species from the orders EPT, and the most similarity in terms of species present relative to the reference station. This is evidenced by the high values for taxa richness, the EPT index, and EPT to chironomid ratio, and the low value for the community loss index. The HBI is a measure of the dominance of environmentally-tolerant taxa; the higher the HBI, the more environmentally-tolerant taxa present. The HBI did not vary appreciably and was slightly lower for Walnut Creek (Figure 3-4A).

The stations on Woman Creek below Mower Ditch (WOP01 and WOP02) had a less diverse and robust macroinvertebrate community than stations with sustained flow on Woman Creek. As discussed in Appendix A, diversions by the Mower Ditch reduced the flow in Woman Creek such that lower Woman Creek was dry during summer months. The results of intermittent flow include less area for macroinvertebrates or fish, increased water temperatures, and possible desiccation, all of which favor more environmentally-tolerant taxa different than those found in upper Woman Creek. The drop in the EPT index, EPT/chironomid ratio, and taxa richness at the intermittent stations support this, as does the large increase in the community loss index (Figures 3-4A and 3-4B).

Similar trends in the metrics for Walnut Creek (Figures 3-4A and 3-4B) may be due to the intermittent nature of the flow in this creek, along with reduced habitat quality. Figures 3-1 and 3-2 and Table 3-3 show that the habitat score for the Walnut Creek station (WARI1), even with potential habitat improvements, was lower than the scores for most of the stations on Woman Creek with sustained flow. Most of the taxa at Station WARI1 were also different from those at the Woman Creek reference station. That no scrapers were found at the Walnut Creek station and the scraper filtering collector ratio was zero may be caused by a lack of periphyton due to the long periods of no flow at this station. Field inspections in September 1994 and December 1994 did not find abundant filamentous algae or aquatic mosses which would reduce scrapers, and toxicants are likely to affect filtering collectors more than scrapers (EPA 1989).

Figure 3-5 shows the overall biological condition for the May and June 1991 data relative to the reference site, along with the habitat scores. The biological condition is a composite measure of the health of the benthic community that integrates the effects of the metrics. The higher the value, the closer the community is to the reference station and the less the potential impairment.

Figure 3-5 indicates the following results:

1. The stations with sustained flow on Woman Creek (SW039, SW033, WORI3, WORI1, and SW026) generally had overall higher biological condition ratings;

these stations also had higher habitat ratings. The exception to this is Station SW026 which had a relatively low biological condition rating.

2. The biological condition was lower at Stations WOP01, WOP02, and WARI1 which had long periods of no flow. These three stations also have relatively lower habitat scores, even if adjusted for reversible habitat alterations (Table 3-3, Figure 3-2).

3. Figure 3-5 suggests that habitat, including flow regime, limited the macroinvertebrates in lower Woman Creek and Walnut Creek in 1991.

4. Based on criteria presented in EPA's *Rapid Bioassessment Protocols*, all the stations on Woman Creek with sustained flow were either "nonimpaired" or "slightly impaired," except for SW026 which was "moderately" impaired. The stations on Woman Creek below the Mower Ditch (WOP01 and WOP02) and on Walnut Creek were also "moderately impaired."

The 1994 macroinvertebrate data were collected from Walnut Creek downstream of Indiana Street and from Walnut and Big Dry Creeks below Great Western Reservoir (Figure 2-1). As described in Section 2.3, two types of samples were taken: (1) Surber samples during baseflow conditions in July 1994, and (2) drift-net samples during a several day release event from Pond A-4 in September 1994. The 1994 data set was analyzed to determine the effects of ammonia concentrations on the macroinvertebrate community in the lower reaches of Walnut Creek. Habitat was also assessed for possible impacts. It should be noted that a suitable reference station did not exist so that only the absolute values of the metrics that could be calculated were analyzed. The values for these metrics are shown with habitat scores for Surber and drift-net samples in Figures 3-6 and 3-7, respectively. The metrics are shown against un-ionized ammonia concentrations at the time of sampling in Figures 3-8 (A, B, and C) and 3-9 (A, B, and C).

Surber sample data from July 1994 (Figures 3-6 and 3-8) are difficult to interpret. There is not a large variation in the values of several metrics. While some trends are evident in the metrics calculated, the metrics are poorly related to habitat or ammonia concentrations. Figure 3-6 shows that taxa richness and the percent contribution of the dominant taxon were lowest at station D1 on Walnut Creek just west of Indiana Street. This indicates that the macroinvertebrates consisted

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of relatively similar numbers of a few taxa. However, these results do not appear to be related to habitat quality or un-ionized ammonia levels: the habitat score was lower at Station D2, and un-ionized ammonia was higher at three of the other four stations (Figure 3-8). Lack of flow at Station D1 may be a more important factor than habitat or ammonia levels. The 1994 data are consistent with the 1991 data which found the macroinvertebrate community at WARI1, located approximately 1,500 feet upstream of D1, to be impoverished compared to other stations sampled.

Figures 3-6 and 3-8 indicate that the taxa richness and the EPT/chironomid ratio generally decreased in Walnut Creek below Great Western Reservoir (Stations D2, W1, and W2), while the HBI and percent contribution of the dominant taxon generally increased. These results exhibit an apparent decrease in health of the macroinvertebrate community which is not readily explained by habitat quality or un-ionized ammonia concentrations. For example, un-ionized ammonia decreased and the habitat rating increased between stations D2 and W1, but taxa richness and the EPT/chironomid ratio decreased at W1 (Figures 3-6 and 3-8). Other factors may explain the results, including the presence of aquatic vegetation, differences in other water quality parameters, or habitat factors not included in the habitat assessment.

Figure 3-8 shows that differences in un-ionized ammonia levels are poorly related to the metrics calculated and there is no clear trend between ammonia and metric values. For example, taxa richness is lowest at Station D1 but un-ionized ammonia is highest at Station W2; or, the highest percent of the dominant taxa was found at BD1 which also had the lowest concentration of un-ionized ammonia. In summary, Figure 3-8 indicates that the levels of un-ionized ammonia at the plant site do not have an effect on the macroinvertebrate community in Walnut Creek below Pond A-4.

The 1994 drift-net data (Figures 3-7 and 3-9) are indicative of the macroinvertebrate drift community during times of discharges from Pond A-4. Figures 3-7 and 3-9 show that taxa richness generally decreased downstream independent of habitat quality and un-ionized ammonia levels. For example, Figure 3-9A shows that the highest taxa richness was found at Stations D1 and D2 which also had the highest levels of un-ionized ammonia. The HBI was relatively constant at the stations sampled, but was higher at Station W2 which had the second lowest level of un-ionized ammonia. As with the Surber sample data, it appears that the ammonia levels in the discharge did not have an influence on the macroinvertebrate community.

3.1.2.2 Pond Data - Benthic Organisms

Data on benthic organisms collected from the A- and B-series ponds, Lindsay Pond (on Rock Creek), and the pond on Walnut Creek at Indiana Street (SW03) in 1991 and 1994 were evaluated to determine the variability in benthic organisms between the ponds. Figure 2-1 shows the locations of the ponds. Lindsay Pond was included as a reference station since this pond represents a relatively undisturbed pond, not influenced by RFETS.

The RBP III and habitat assessment procedure do not apply to ponds. However, similar methods can be used and certain metrics such as taxa richness, the HBI, and percent contribution of dominant taxon reflect the ecological integrity of pond systems (EPA 1995). Therefore, these three metrics were calculated and are shown in Figures 3-10 and 3-11 for the 1991 and 1994 data, respectively.

Figure 3-10 shows that the most diverse macroinvertebrates in 1991 were found in Ponds B-1, B-4, and B-3. The HBI was highest (indicating a more pollution-tolerant community) in Ponds B-5 and B-3; values for the other ponds were relatively close to each other. The percent contribution of the dominant taxon was highest in Ponds B-2, B-5, and SW03 (pond on Walnut Creek at Indiana Street). Figure 3-10 also indicates that: (1) metrics for Lindsay Pond were in the middle range for the ponds sampled, and (2) values for SW03 were also within the middle range. The taxa richness was higher at SW03 than Pond B-5, and the HBI was lower than at Ponds B-3 and B-5. This suggests that the macroinvertebrate community in pond SW03 is within the range of and generally similar to the other ponds sampled.

Figure 3-11 shows the results of the macroinvertebrate data collected in 1994 from the ponds. Pond SW03 was not sampled in 1994. There are considerable differences in the metrics calculated from the 1994 data versus 1991. For example, Lindsay Pond had a more diverse community with a more even species distribution in 1994, and the community in B-3 was much less diverse and dominated by fewer taxa. The 1994 data indicate that considerable variability exists over time in the nature of the macroinvertebrates in the ponds. Causes of this variability have not been assessed in this study. Factors that are likely important in controlling the macroinvertebrate community both in time and between ponds include hydraulic retention time, water temperature, dissolved oxygen, water level fluctuations, and water quality.

3.1.2.3 Fish Data

Data on fish in Woman, Walnut, and Big Dry Creeks and the ponds on the site were collected by EG&G in 1991 and the Colorado Division of Wildlife (CDOW) in 1992 and 1993. The data were collected for a qualitative assessment of fish communities in the subject creeks and ponds. Rapid Bioassessment Protocol Level V (RBP V) in the EPA guidance document is for conducting fish assessments. This protocol was not followed in this study; however, several of the metrics were calculated to ascertain major differences in the fish communities present.

Table 3-5 provides a list of species, and Figure 3-12 shows the metrics calculated for each of the creeks. The most obvious finding from Table 3-5 and Figure 3-12 is the impoverished nature of the fish community in Walnut Creek. Walnut Creek had the lowest numbers of total species, intolerant species, and sucker species; the highest numbers for these metrics were found in Big Dry Creek above the confluence with Walnut Creek.

The total number of fish species is typically directly related to stream size for small streams. However, since Woman and Walnut Creeks are of comparable size, other factors such as flow, habitat diversity, and the presence and size of permanent pools are likely important.

Both the number of intolerant species and sucker species typically increase with creek size in small creeks. Suckers are relatively long-lived and sensitive to physical and chemical habitat degradation. Likewise, sensitive species such as trout will be affected by degradation. The higher numbers for these metrics in Big Dry Creek may be due to stream size. However, lower values in Walnut versus Woman Creek may be due to other factors, as previously mentioned.

Figure 3-13 shows the metrics for the C-ponds, SW03, and A- and B-series ponds. No suckers or intolerant species were found in any of the ponds. This figure also indicates that the highest numbers of species were found in Pond C-1, and only one species was found in SW03 and the A- and B-series ponds.

The similarity in fish species between SW03 and the A- and B-series ponds is likely due to the similar physical characteristics of these ponds, and the likely source of fish species for SW03 is the A- and B-series ponds. A more detailed evaluation of the fish communities sampled would require development of local species and water body relationships.

3.1.3 Summary of Bioassessment

The bioassessment findings are summarized as follows:

1. Available data indicate that the macroinvertebrate community in Walnut Creek downstream of the A- and B-series ponds and upstream of Indiana Street is not as diverse or robust as that in Woman Creek above the Mower diversion. Recent observations indicate that there is no macroinvertebrate community in this segment of Walnut Creek, except for the very downstream reach (approximately the last 500 feet upstream of Indiana Street), or in Woman Creek below the Mower Ditch, due to the lack of flow.

2. The present habitat of Walnut Creek below the A- and B-series ponds is of lower quality than Woman Creek. Large differences exist in regard to flow conditions, the presence of habitat types, and the diversity and productivity of the riparian zone.

3. Maintenance of a perennial flow regime or other reasonably feasible habitat improvements to Walnut Creek would not result in habitat equivalent to that in Woman Creek.

4. Data indicate that the macroinvertebrate community in Walnut Creek below Pond A-4 is not adversely affected by ammonia concentrations during periods of releases from this pond. If an intermittent flow regime is continued in Segment 4 of Walnut Creek, potential effects of un-ionized ammonia on aquatic organisms will be low since little or no macroinvertebrate community will exist.

5. Data show that the characteristics of aquatic life in the pond in Walnut Creek at Indiana Street are generally similar to those in the A- and B-series ponds.

3.2 CONCLUSIONS

The bioassessment results presented above, in conjunction with the flow analyses in Appendix A, indicate that lower Walnut Creek is significantly different from Woman Creek in terms of physical characteristics, flow regime, and aquatic life. The bioassessment found that lower Walnut Creek has significantly poorer habitat and an impaired macroinvertebrate community compared to Woman Creek. Operational practices at RFETS detention ponds cause a lack of flow and long periods of a dry channel in lower Walnut Creek which has a major impact on aquatic life. However, habitat evaluations indicate that even with a constant base flow, other characteristics such as riparian overstory and stream substrate conditions would prevent lower Walnut Creek from achieving the same biological health that currently exists in Woman Creek.

Flow conditions and habitat conditions which limit the biological health of lower Walnut Creek also limit the potential impacts to aquatic life from un-ionized ammonia in discharges to this segment. Ammonia concentrations in the ponds fluctuate in response to operational practices and natural processes and can exceed current standards; however, the available data show poor correlation between ammonia concentrations in pond water discharges and impairment of aquatic life in the ponds or in lower Walnut Creek below the ponds. Furthermore, sampling data indicate significant reductions in un-ionized ammonia concentrations as water discharged from Pond A-4 travels through the reach, such that the Segment 4 un-ionized ammonia standard is achieved prior to reaching Indiana Street. Existing un-ionized ammonia concentrations appear to have no detrimental impacts on the uses or biological health of the receiving or downstream segments.

REFERENCES

U.S. Environmental Protection Agency. 1989. *Rapid Biaoassessment Protocols for Use in Streams and Rivers - Benthic Macroinvertebrates and Fish.* EPA/440/4-89/001.

Ward and Kondratieff. 1992. *An Illustrated Guide to the Mountain Stream Insects of Colorado.* Niwot, Colorado: University Press of Colorado.

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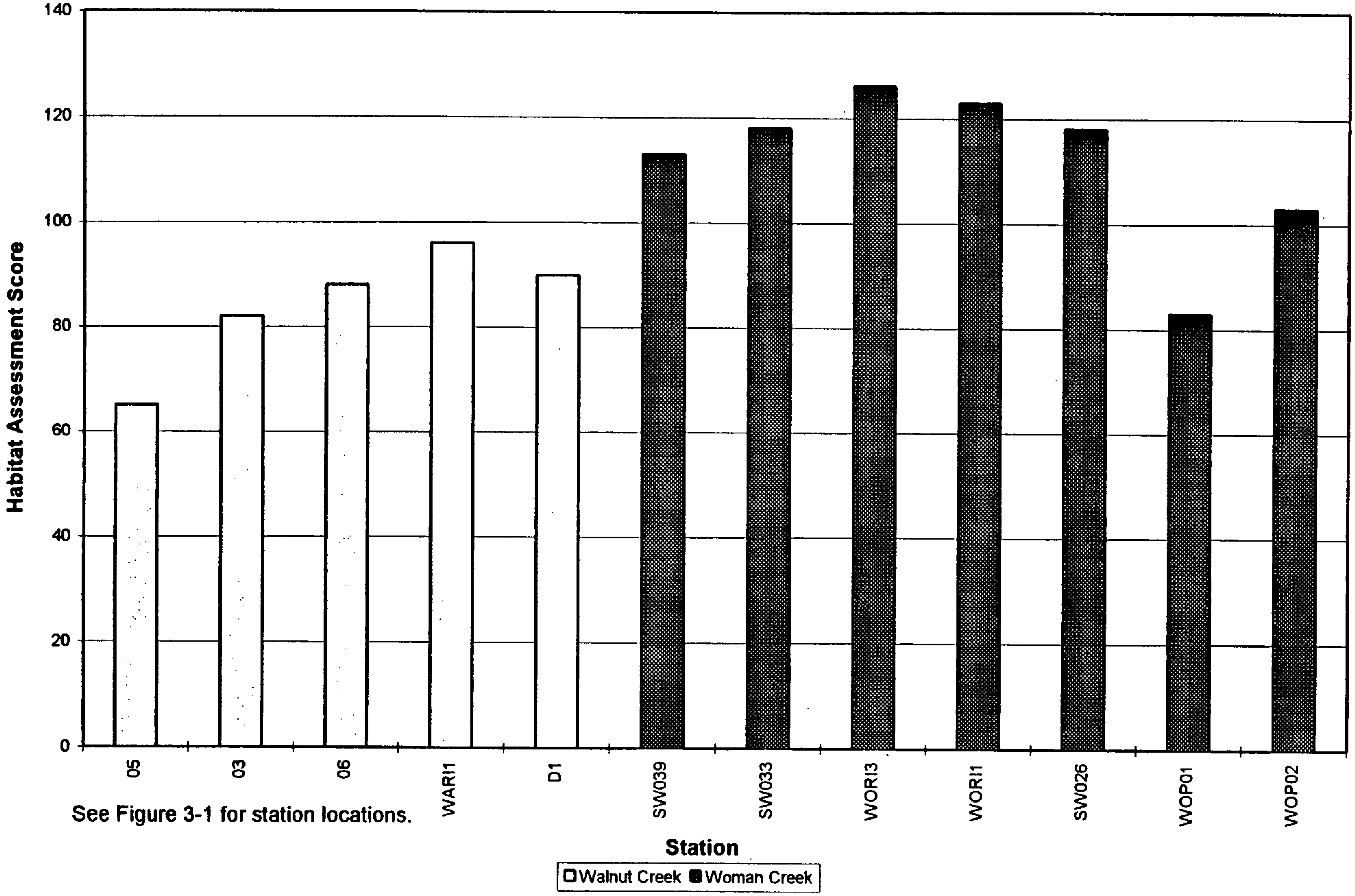
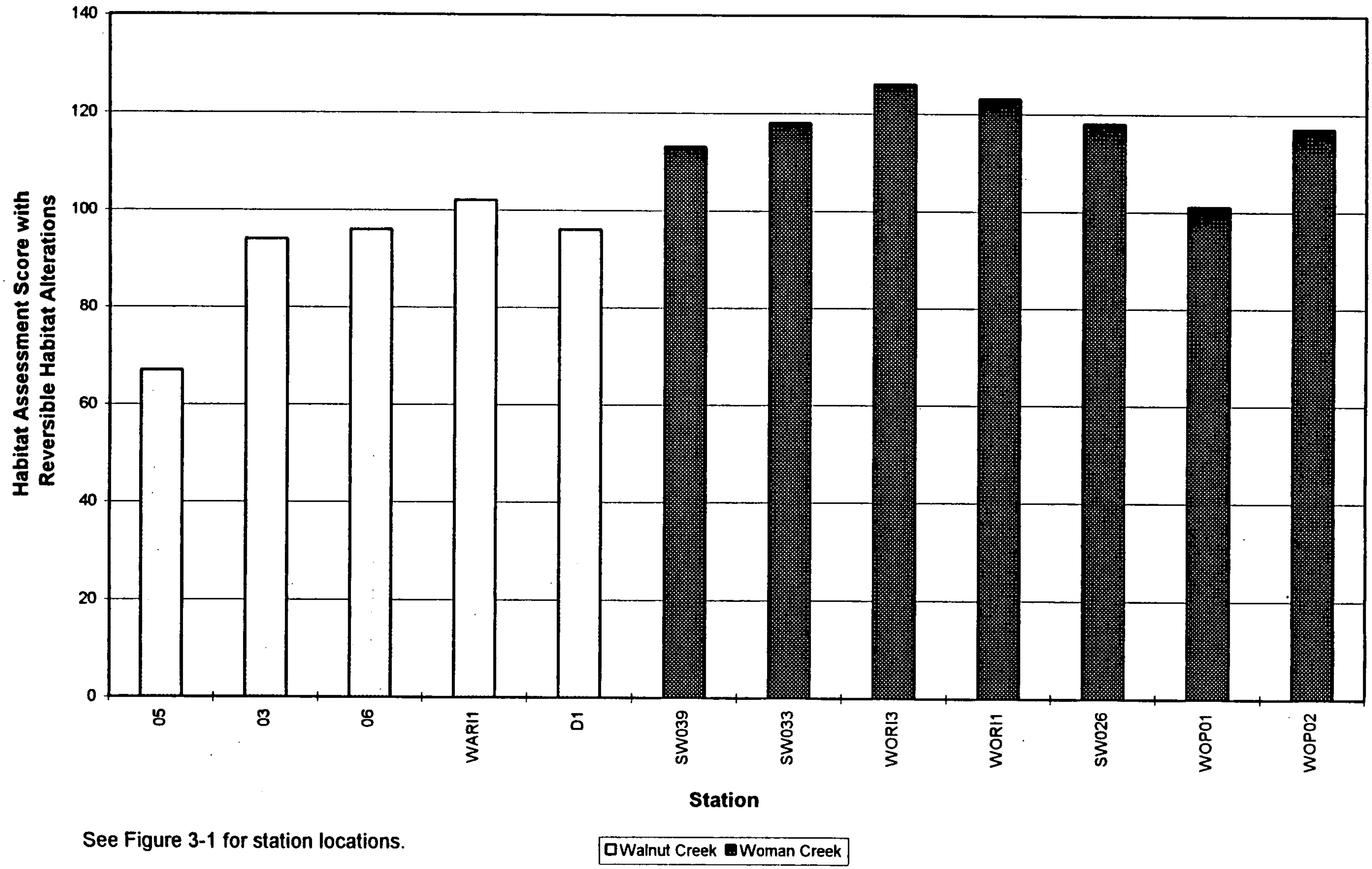
Figure 3-1
Habitat Assessment Scores



See Figure 3-1 for station locations.

Figure 3-2
Habitat Assessment Scores with Reversible Habitat Alterations



See Figure 3-1 for station locations.

Figure 3-3
Habitat Comparison Between Existing Segment 4 and Segment 5 of Walnut Creek

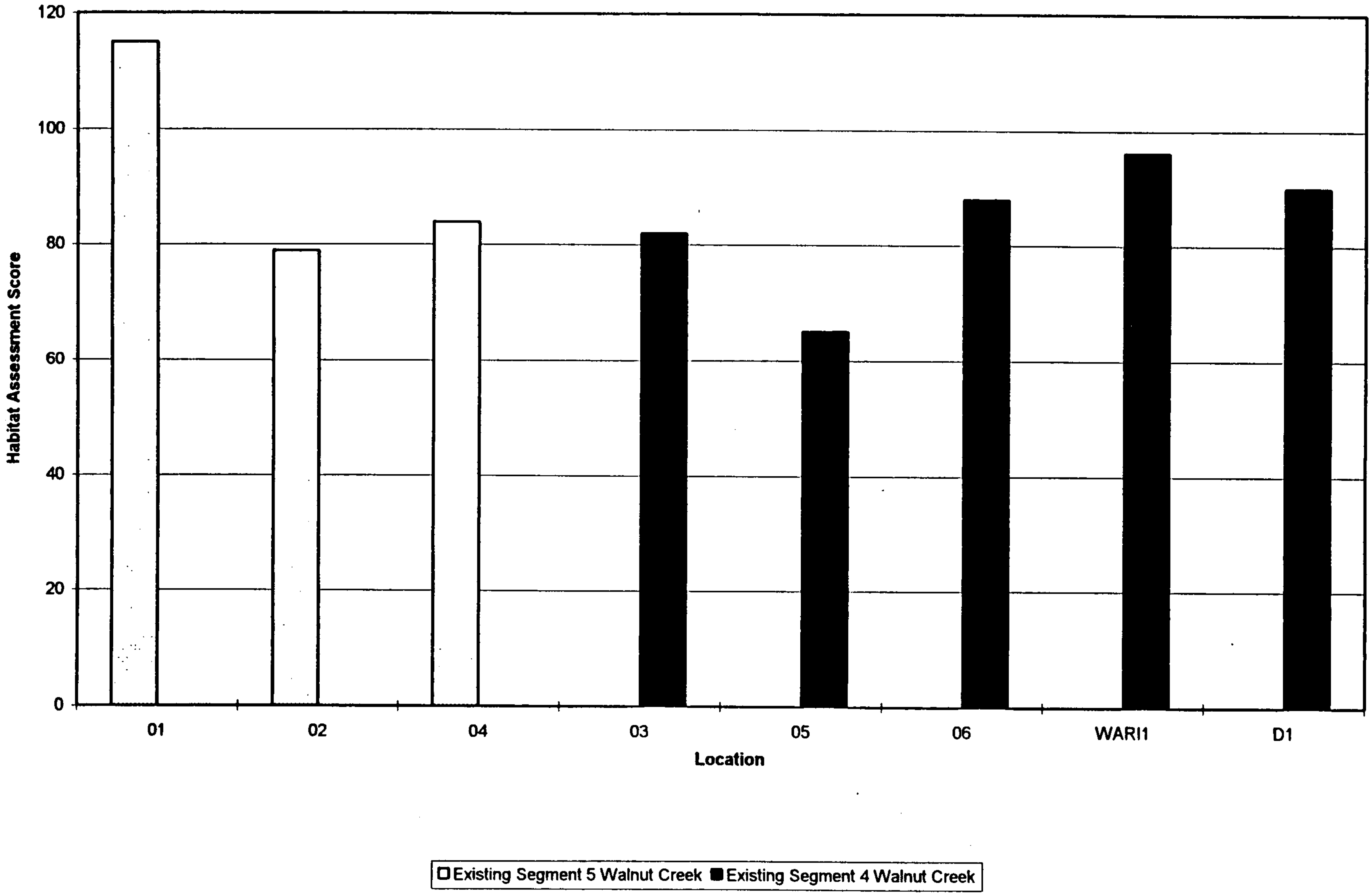


Figure 3-4A
Values of Metrics for May-June 1991 Benthic Data

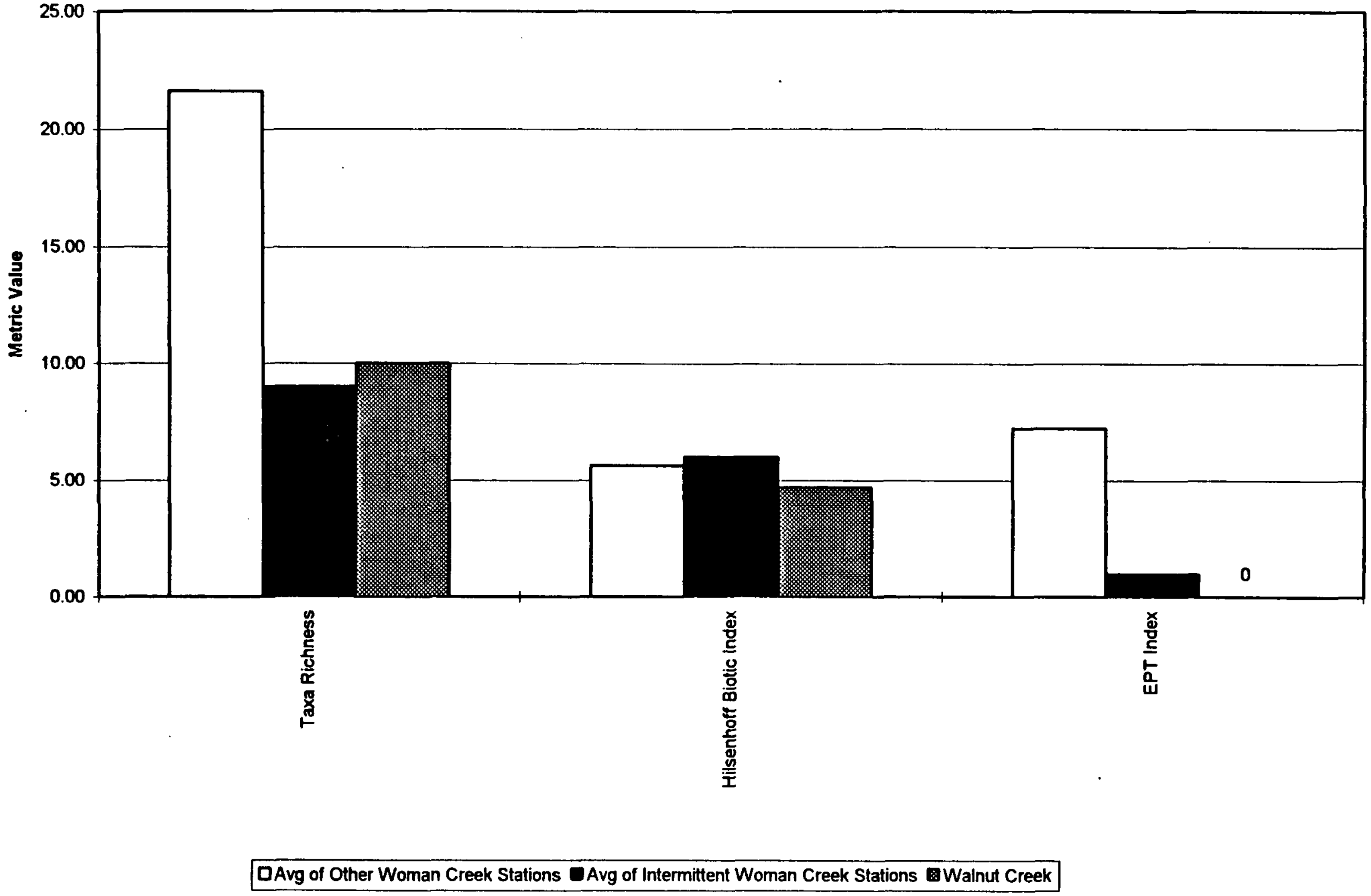


Figure 3-4B
Values of Metrics for May-June 1991 Benthic Data

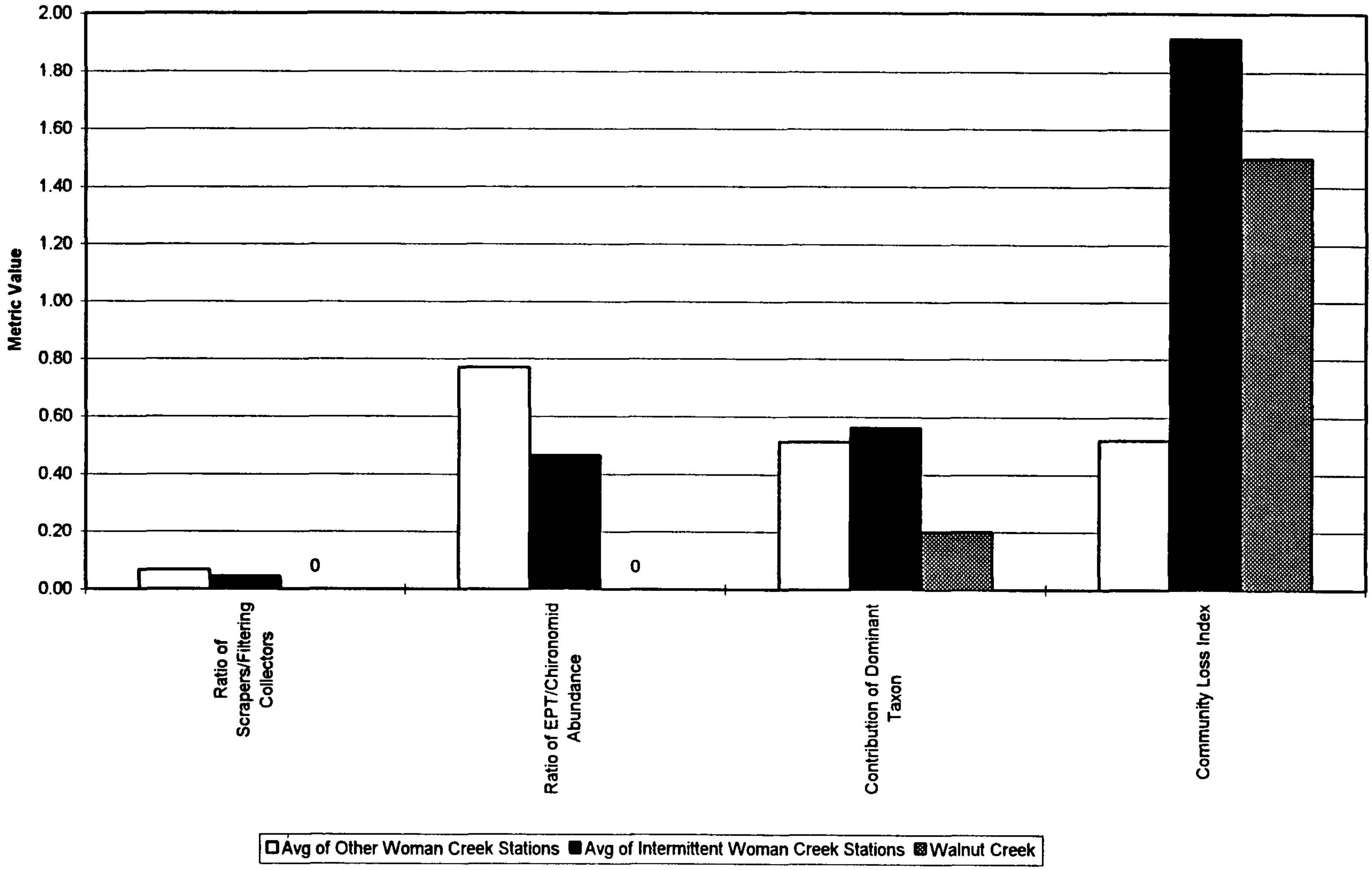


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Figure 3-5
Overall Biological Condition Relative to the Reference Station For May-June 1991 Benthic Data

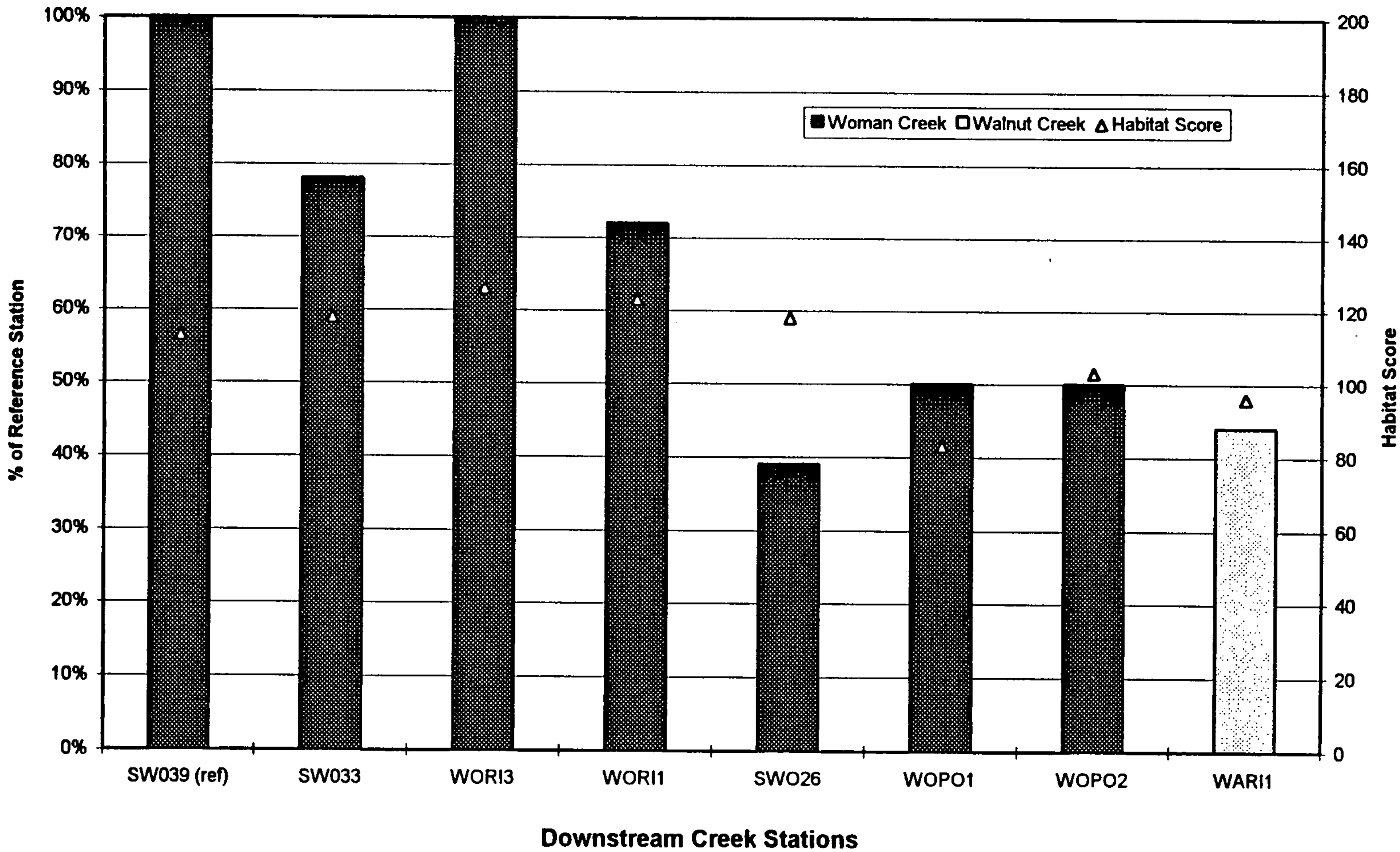

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Figure 3-6
Values of Metrics and Habitat Scores for July 1994 Surber Sampler Data

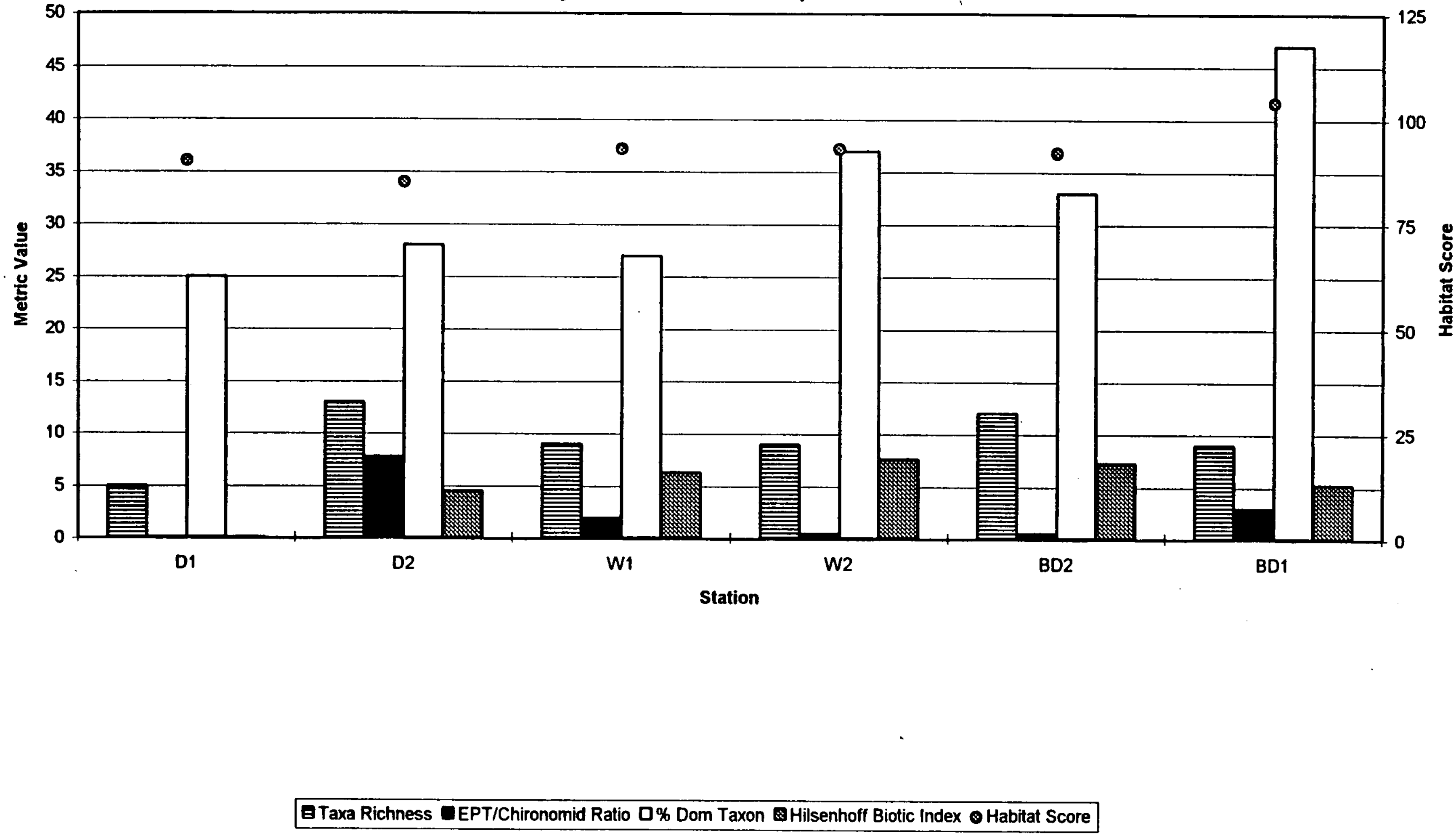

Figure 3-7
Values of Metrics and Habitat Scores for September 1994 Drift Net Data

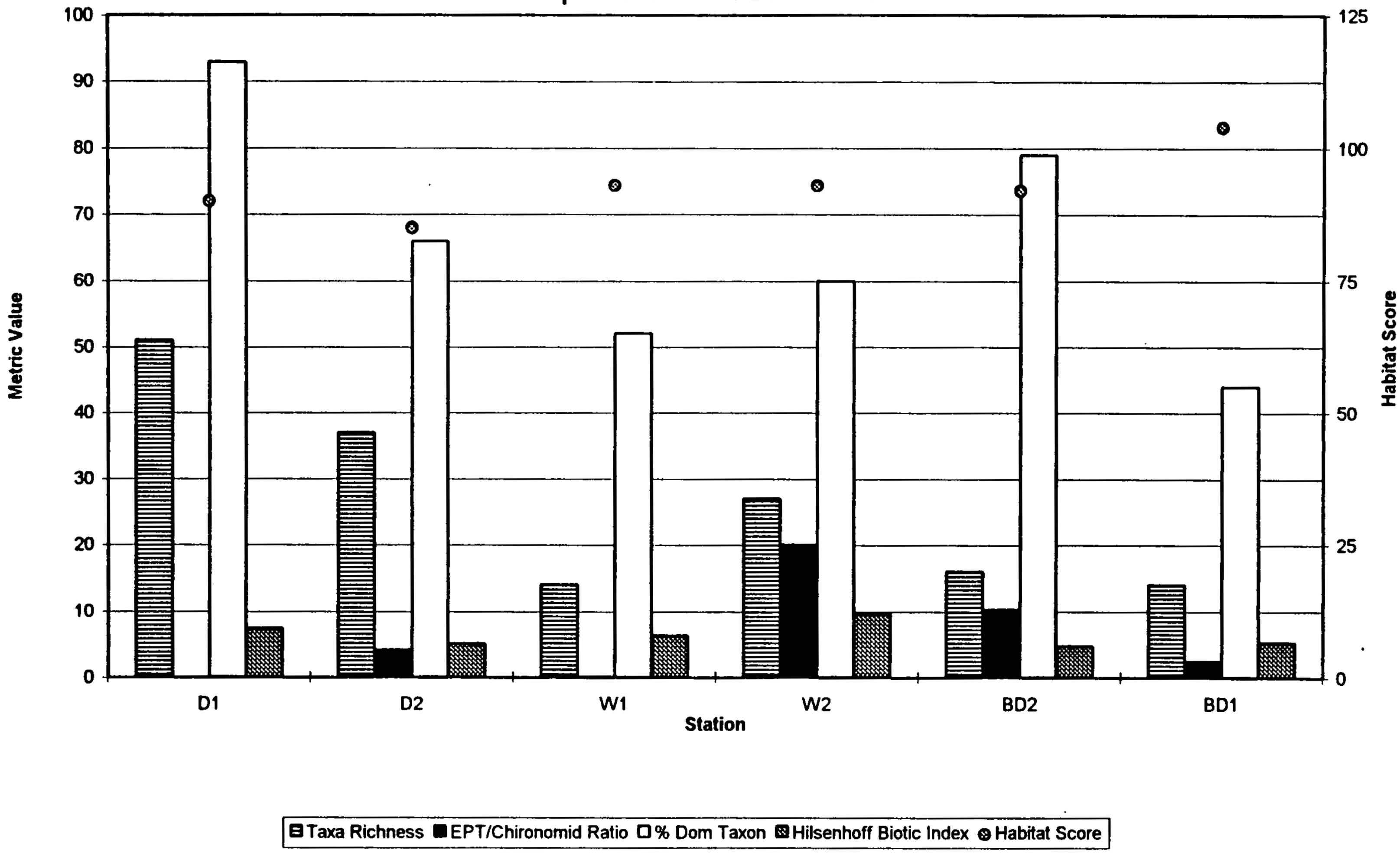

Figure 3 - 8A

Taxa Richness versus Un-ionized Ammonia for July 1994 Surber Sampler Data

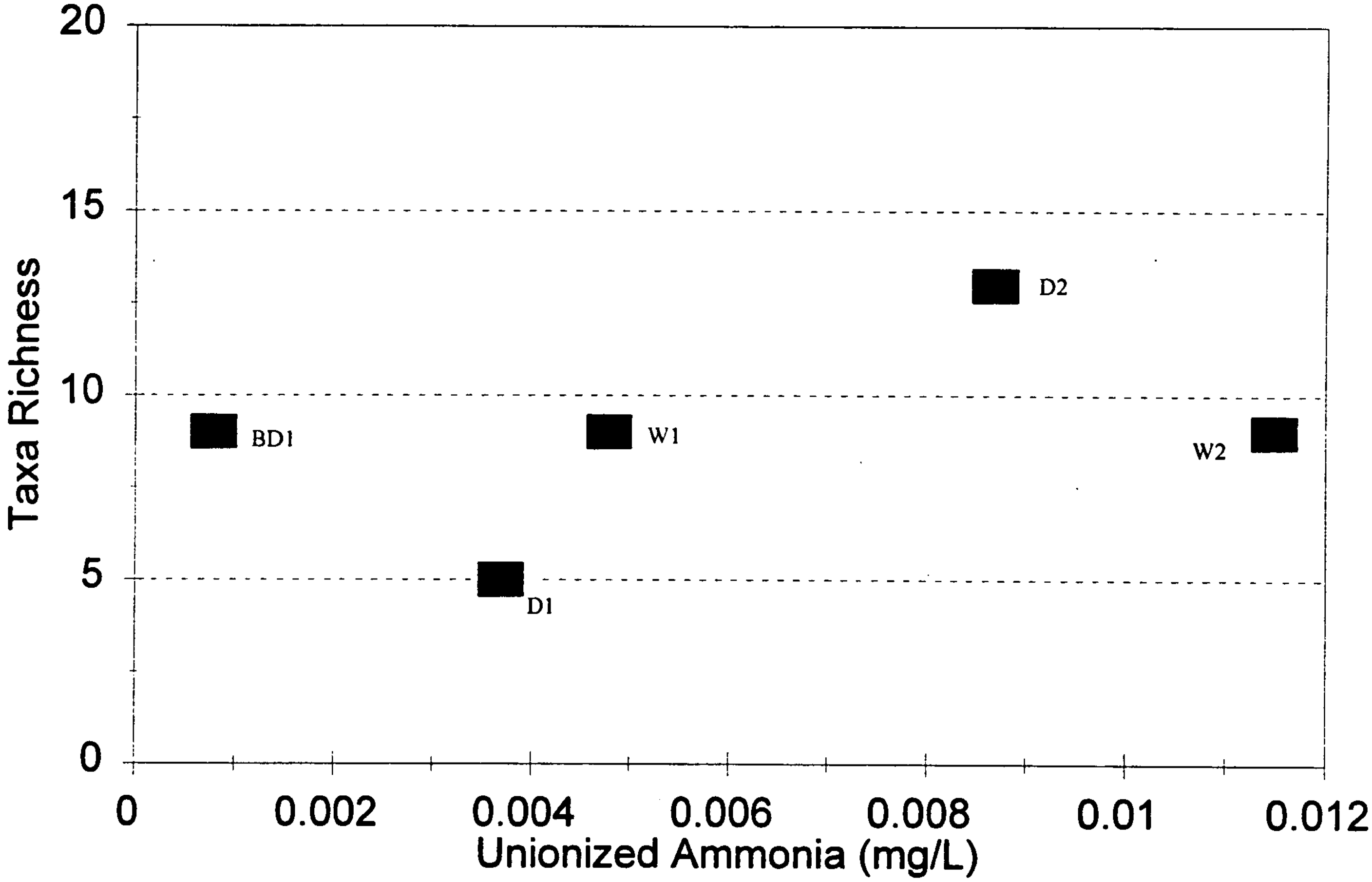

Figure 3 - 8B

% Contribution of Dominant Taxa versus Un-ionized Ammonia for July 1994 Surber Sampler

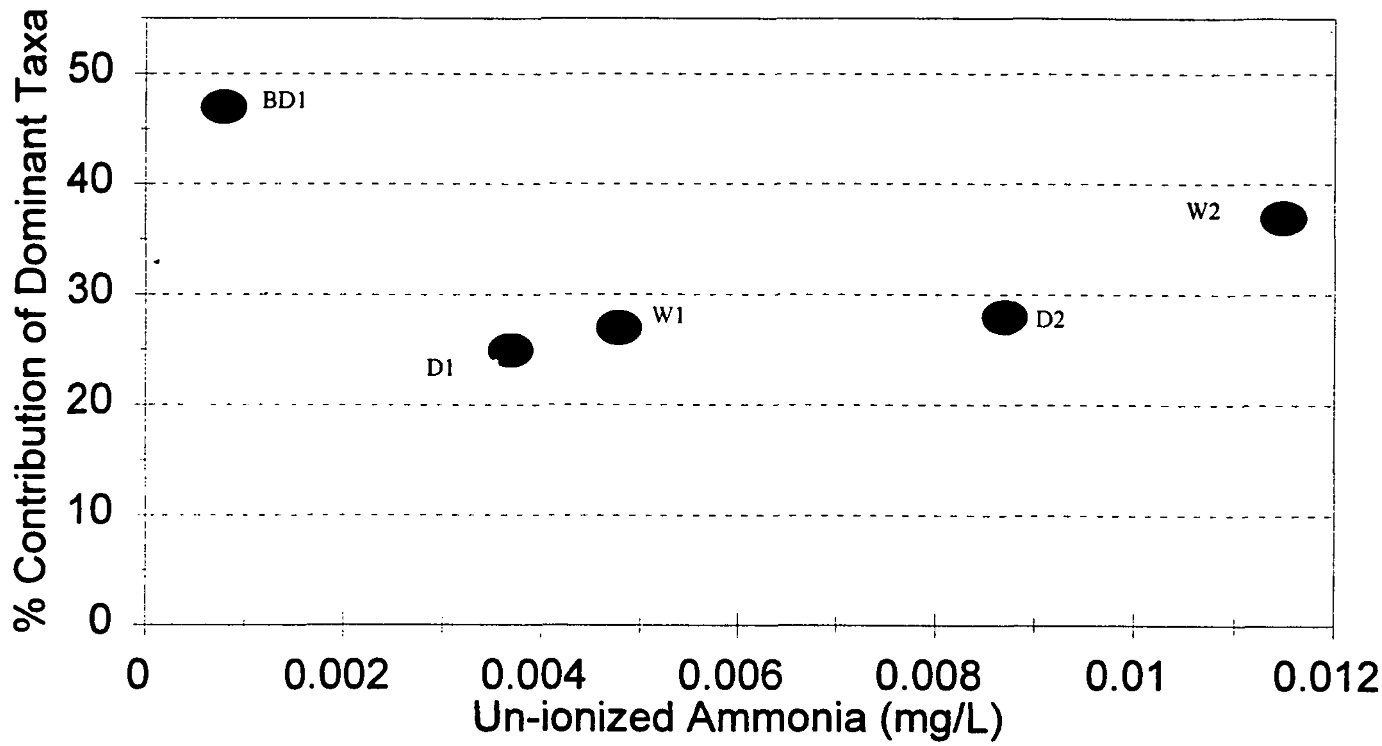

Figure 3 - 8C

Hilsenhoff Biotic Index versus Un-ionized Ammonia for July 1994 Surber Sampler Data

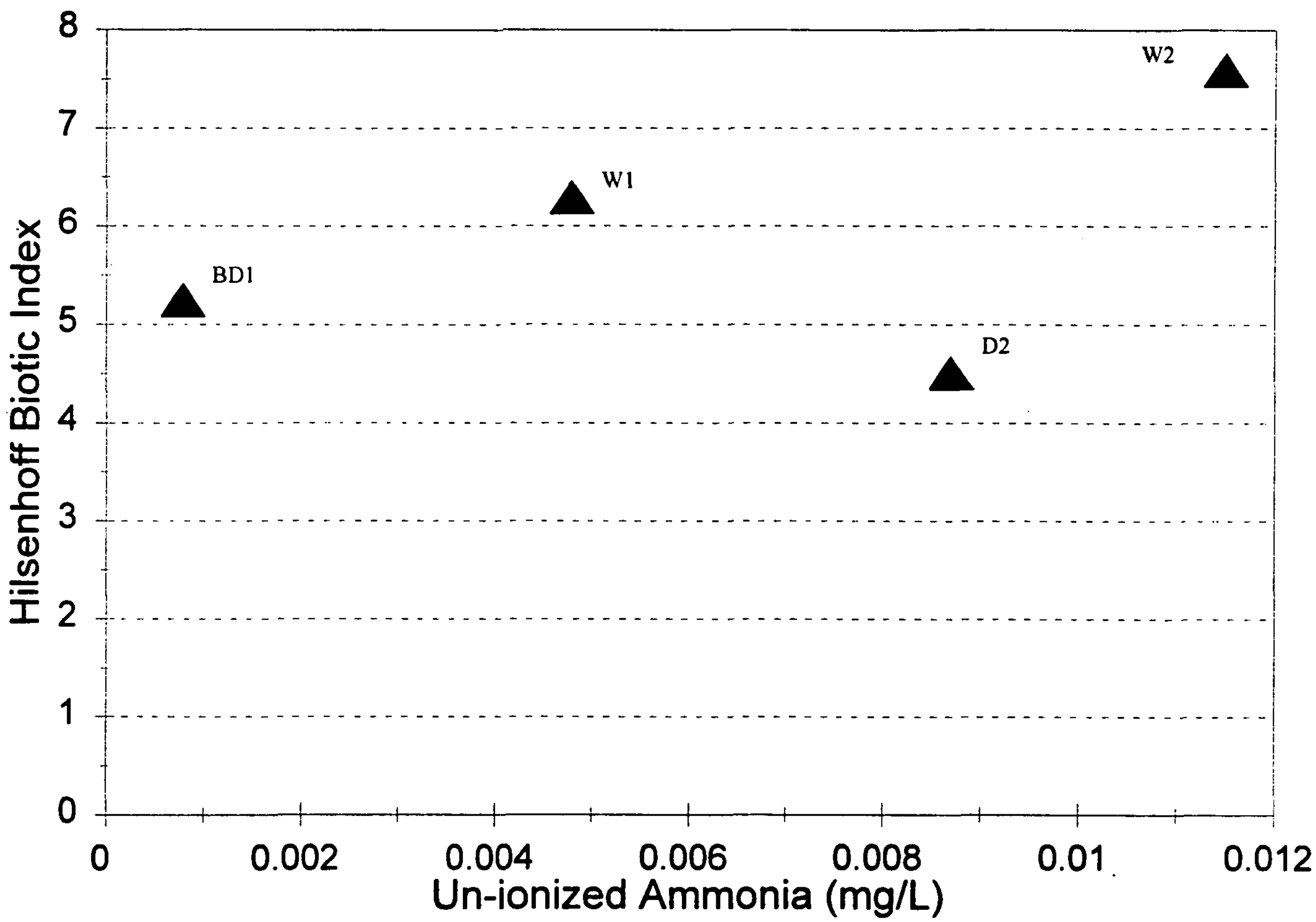

Figure 3 - 9A

Taxa Richness versus Un-ionized Ammonia for Sept. 1994 Drift Net Data

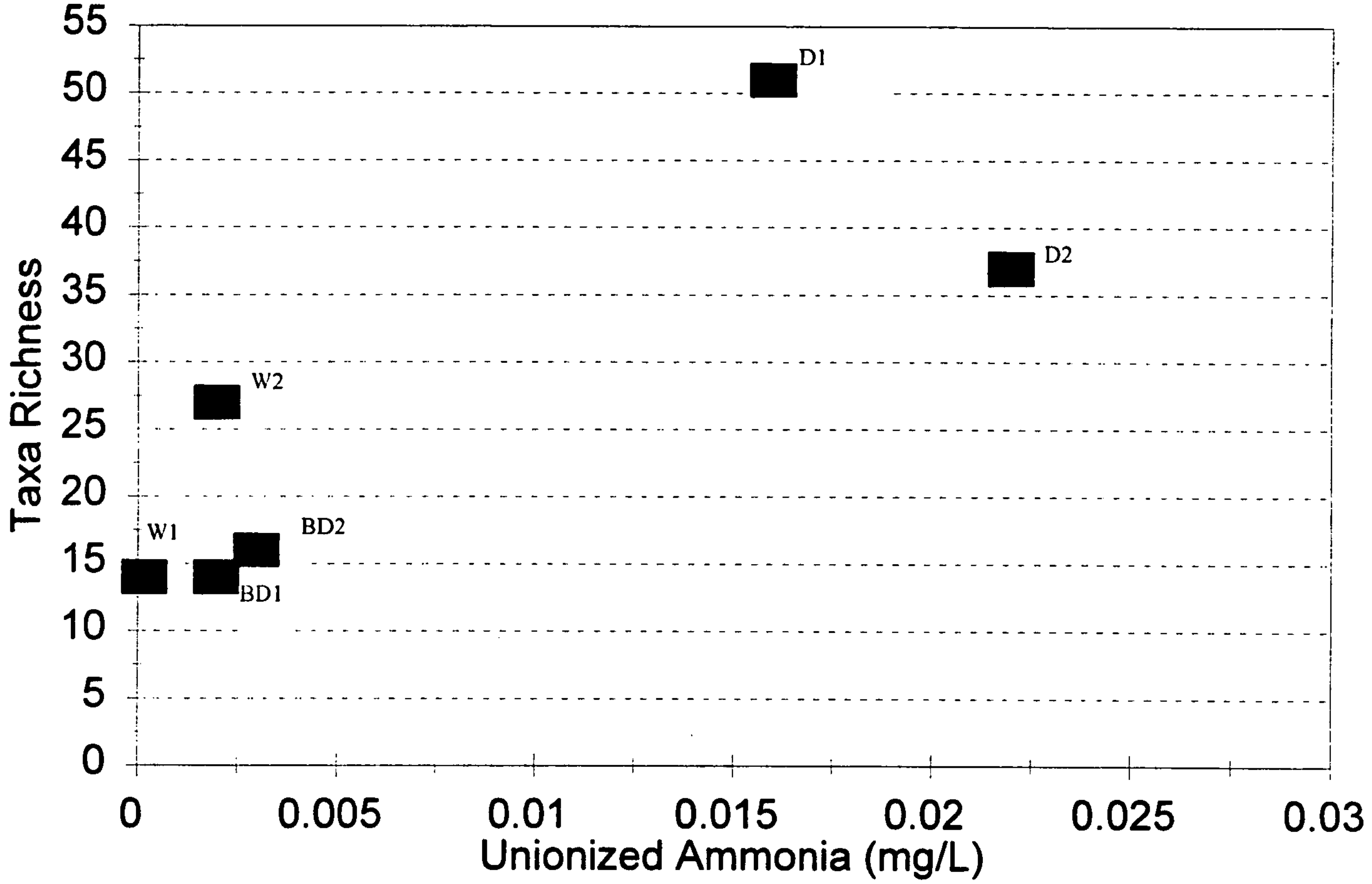

Figure 3 - 9B

% Contribution of Dominant Taxa versus Un-ionized Ammonia for Sept. 1994 Drift Net Data

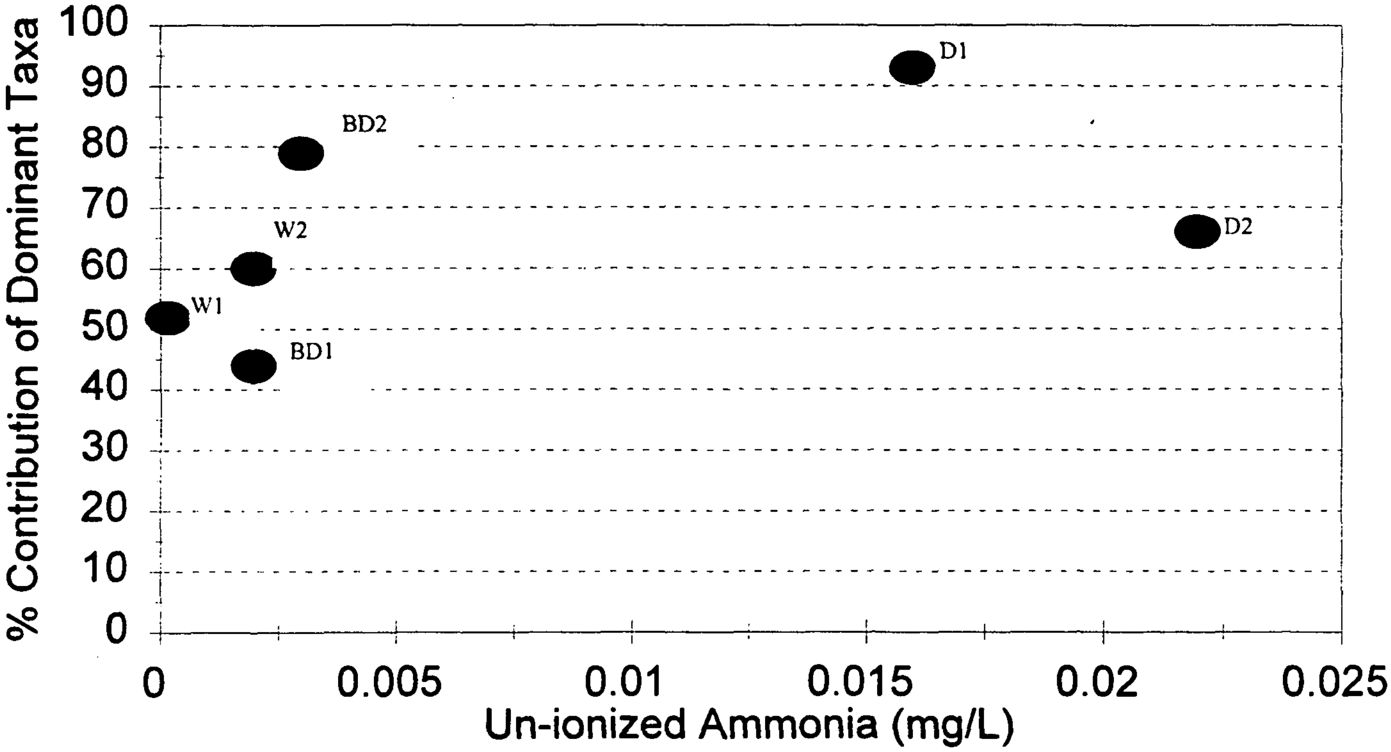

Figure 3 - 9C

Hilsenhoff Biotic Index versus Un-ionized Ammonia for Sept. 1994 Drift Net Data

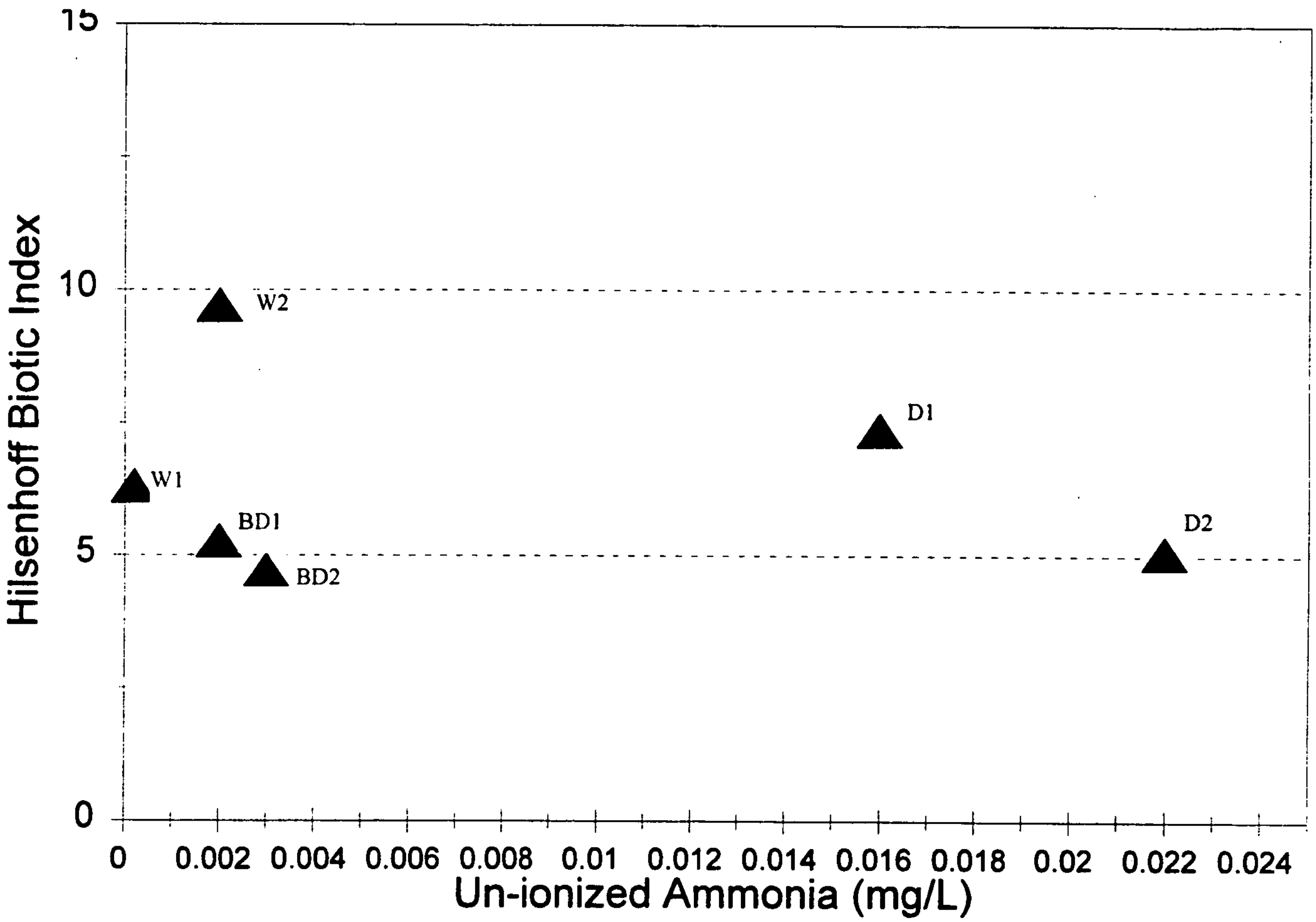

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Figure 3-10
Benthic Information from 1991 Pond Data

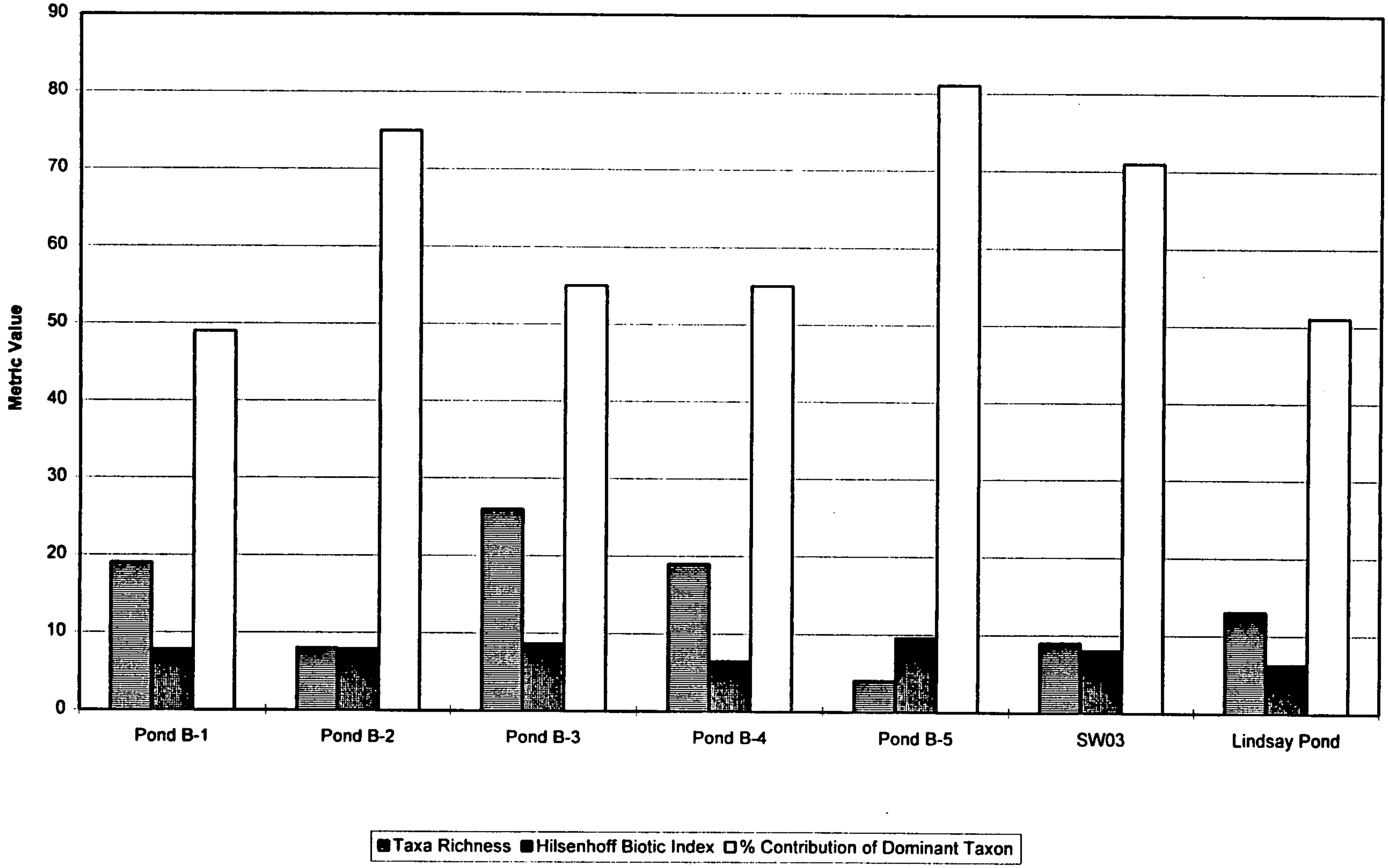

Figure 3-11
Benthic Information From 1994 Pond Data

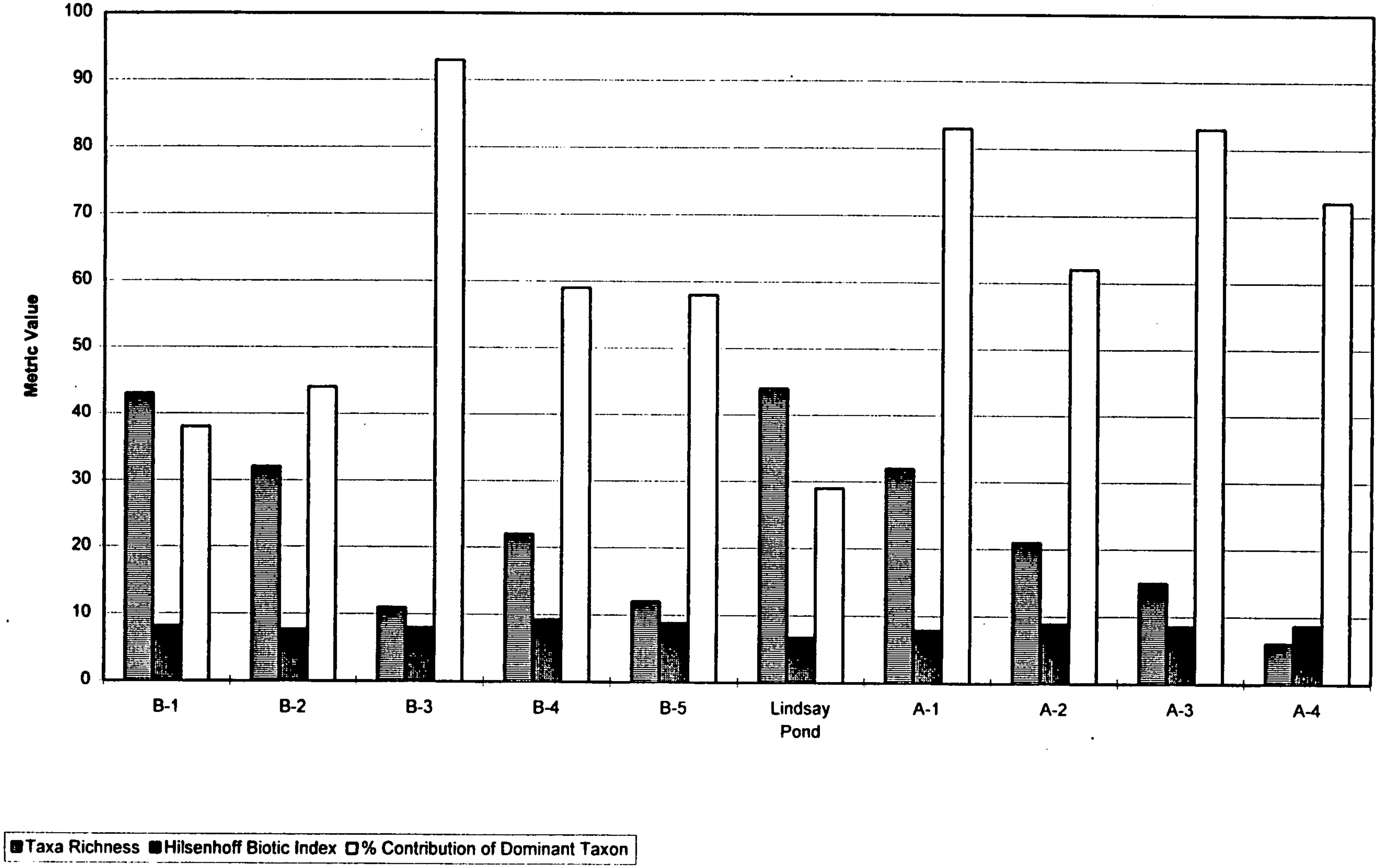

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Figure 3-12
Fish Data for the Creeks

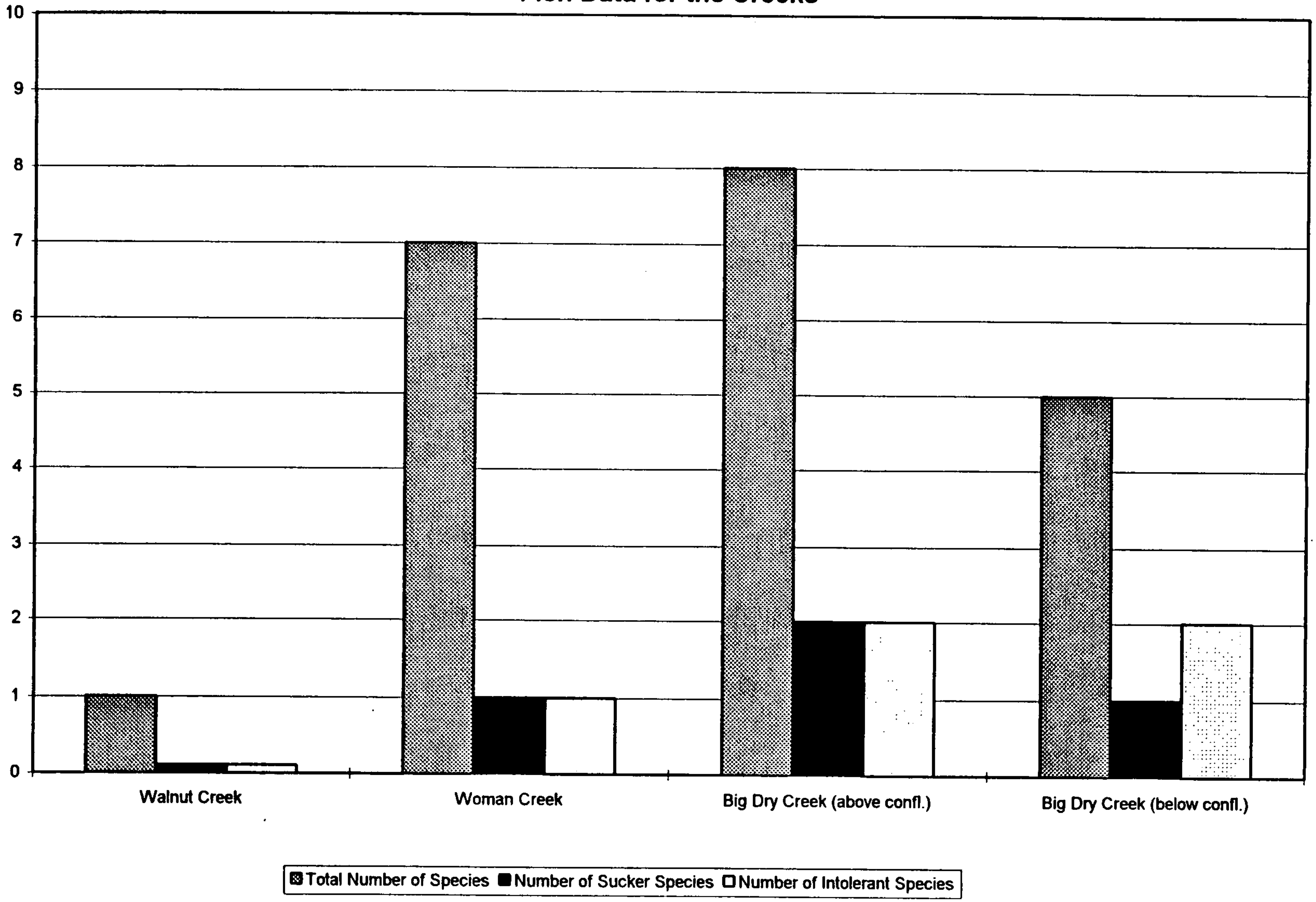

Figure 3-13
Fish Data for Ponds

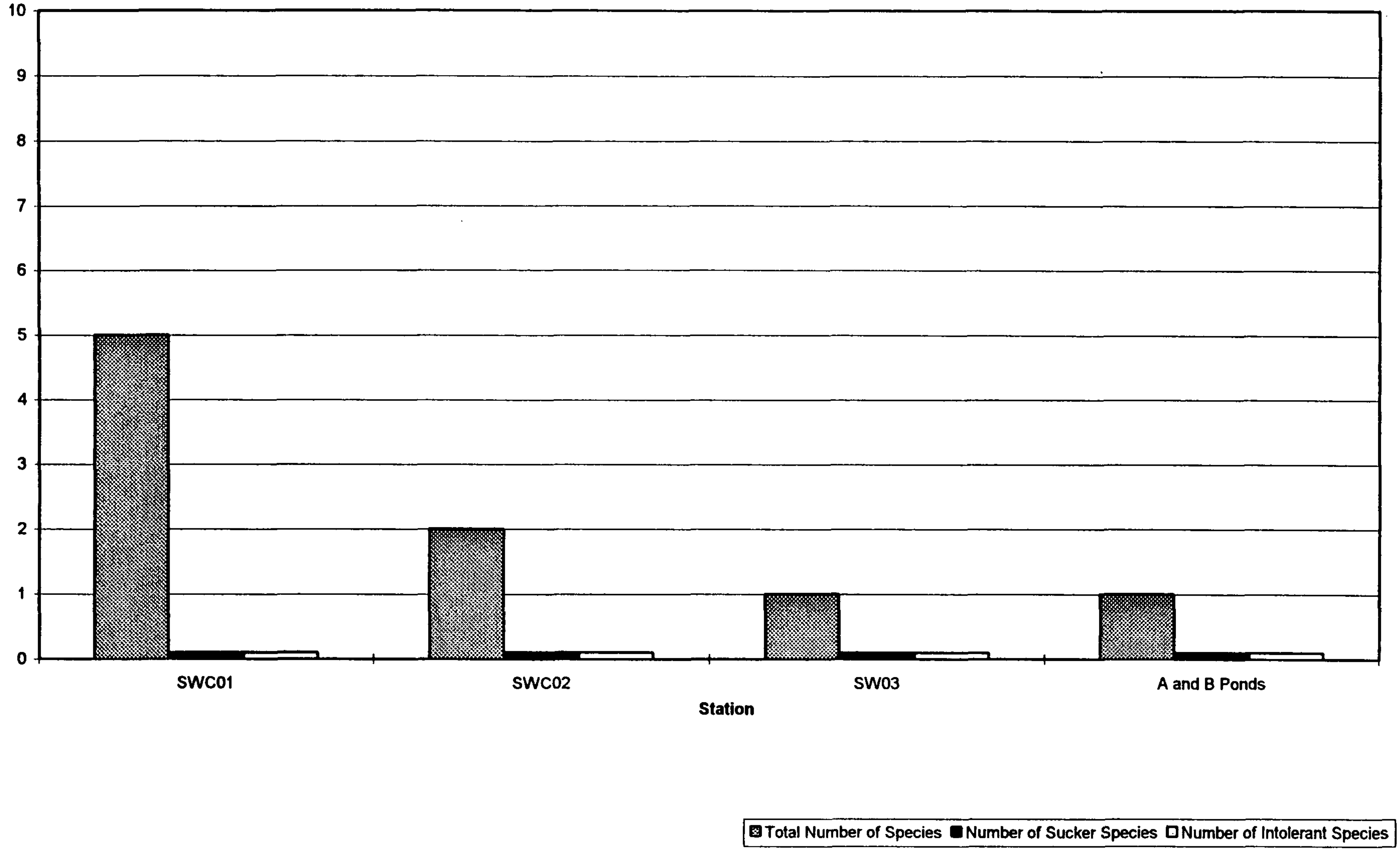

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TABLE 3-1
HABITAT ASSESSMENT OF WALNUT AND WOMAN CREEKS ON ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Station ID	Location[1]	Description/Comments	Habitat Score[2]
01	Above Pond A-1 but below GS-13	Flow was approximately 0.25 cfs. The water was cool and clear with little sediment on the rocks. Bottom substrate was approximately 80 percent cobble, large gravel, or rocks.	115
02	Above Pond A-3	The bottom substrate was about 40 percent gravel or rock. There was a thick layer of fine sediment on the bottom. Flow was slightly less than above Pond B-5 and was approximately 0.1 cfs. Streamside cover was a mix of shrubs and grass.	79
03	Below Pond A-4	There was no flow at the site. Bottom substrate was approximately 70 percent gravel or other larger rocks. The channel was essentially uniform in depth with few pools. The bank showed a moderate amount of erosion, probably due to periodic releases of water from Pond A-4.	82
04	South Walnut Creek above Pond B-5	Flow at this station was about 0.25 cfs. The bottom substrate was approximately 50 percent gravel or larger material. Streamside cover was a mix of shrubs and grasses. This is one of the better creek reaches between the ponds.	84
05	Below Pond B-5	There was no flow at this station. Bottom substrate was less than 10 percent gravel or larger material. The stream channel showed evidence of terrestrial plant encroachment. The dominant streamside cover was grass.	65
06	Below confluence of South and North Walnut Creeks	The creek had pools of standing water but no visible surface flow. There were alternating wet and dry sections of the channel. The channel bottom was approximately 80 percent gravel or larger material. There was little evidence of erosion on the channel bank. The dominant streamside vegetation was grass. The channel was straight and narrow with few pools or riffles.	88
WARI1	Lower Walnut Creek about 500 yards above the Walnut and Indiana Pond	Bottom substrate was about 80 percent cobble or gravel and cobble. Flow was very low at approximately 5 gpm (0.01 cfs). Walking up the stream, the channel had alternating wet and dry sections. There were some terrestrial grasses within the channel. Streamside cover was mostly grasses with some trees.	96

8

TABLE 3-1
(Page 2 of 3)

Station ID	Location[(1)]	Description/Comments	Habitat Score[(2)]
D1	Below Walnut and Indiana Pond west of Indiana Street	The bottom channel was about 70 percent gravel and cobble. Flow was low at approximately five gpm. There were essentially no pools or riffles, with the channel very straight and shallow. Streamside cover was dominated by grasses.	90
SW39	Woman Creek at SW39	Flow in the creek was low at approximately five gpm (0.01 cfs). The whole bottom channel was wet with some relatively larger pools. The channel was not incised and was about one to two feet across. The channel was wider than that at Walnut Creek. Less grasses and weeds occurred within the channel than within Walnut Creek.	113
SW33	Woman Creek at SW33	Bottom substrate was predominantly cobble. Flow in the creek was approximately 0.1 cfs. The channel was larger and more incised than upstream, with slightly greater flow. The streamside cover was a combination of shrubs, trees, and grasses.	118
WORI3	Approximately 300 feet upstream of Pond C-1	Bottom substrate predominantly cobbles. Flow around 0.4 cfs. Some pools and riffles. Vegetation predominantly shrubs.	126
WORI1	Woman Creek at WORI1	The bottom substrate at this station is predominantly cobble. The water was clear and the estimated flow was 0.4 cfs. (At SW26, downstream of WOR11, a continuous flow meter recorded a flow of 0.33 cfs.) There was little evidence of any benthic organisms. Streamside cover was excellent and included shrubs, grasses, and trees. The limiting habitat constraint in this area appears to be the size of the channel, rather than flow or bottom substrate. The channel was approximately two to three feet wide at this point.	123
SW026	Approximately 100 feet downstream of Pond C-1	Includes relatively large pool below culvert and riffle downstream. Substrate predominantly cobbles. Flow around 0.4 cfs. Fairly distinct pools and riffle.	118
WOP01	Woman Creek at WOP01 downstream of the Mower diversion	The stream bed was dry and filled with leaves and apparently had not seen any flow for quite some time. Streamside cover was a mix of grass, trees, and shrubs. The channel characteristics in terms of size were similar to upstream on Woman Creek.	83

σ

TABLE 3-1
(Page 3 of 3)

Station ID	Location[1]	Description/Comments	Habitat Score[2]
WOP02	Approximately 500 feet upstream of Indiana Street	No flow in creek. Standing water in several pools. Creek bed filled with leaves but mainly a cobble bottom.	103
D2	50 feet below pond formed by Great Western Reservoir diversion	There was no flow at this location. The channel was covered in cobble, but there was a fine coating of sediment on all of the cobbles. Banks were covered predominantly (95 percent) by grass. The channel was cut down about 4 to 5 feet, but was very straight.	85
W1	Walnut Creek at Old Wadsworth Blvd.	Flow at this location was approximately 0.1 cfs. The bottom substrate was 100 percent gravel, and no larger sized cobble was evident. There was abundant organic matter in the stream channel including fallen cattail and leaves. The channel was only 1 to 2 feet wide. The dominant streamside cover was cattail and grasses, but some willow was also present.	93
W2	Walnut Creek 100 ft. above confluence with Big Dry Creek	Flow at this station was approximately 0.15 cfs. The channel bottom was almost entirely covered with filamentous and macrophytic algae that was growing on the cobble and gravel substrate. The channel itself was quite narrow, being 1 to 2 feet wide. Streamside cover was approximately 70 percent grass and 30 percent shrubs.	93
BD2	Big Dry Creek 150 ft. above confluence with Walnut Creek	Flow at this station was approximately 0.8 cfs. The bottom of the channel was covered with filamentous algae and evidenced sediment deposition. A large (50-foot) cut bank could be seen upstream of the station at the outside of a meander. Two pools, approximately 12-18 inches deep, were also evident.	92
BD1	Big Dry Creek 50 ft. below confluence with Walnut Creek	Flow at this station was approximately 0.9 cfs. The bottom substrate of cobbles was covered with filamentous algae and other organic material such as fallen leaves. Bankside vegetation was a diverse combination of shrubs and grasses with some trees evident.	104

Notes:
(1)See Figure 3-1 for station locations.
(2)See Table 5-2 for scores for each habitat parameter.

TABLE 3-2
HABITAT ASSESSMENT RATING SCORES
(See Table 2-1 for Explanation)

HABITAT PARAMETER	STATION ID[1]																			
	N. Walnut			S. Walnut		Walnut						Woman Creek							Big Dry Creek	
	01	02	03	04	05	06	WARI 1	D1	D2	W1	W2	SW 39	SW3 3	WORI 3	WORI 1	SWO 26	WP 01	WPO 02	BD2	BD1
Bottom Substrate	18	14	18	15	5	18	18	17	19	17	18	17	18	19	18	18	15	16	18	19
Embeddedness	17	6	19	13	18	18	17	18	19	15	3	20	20	20	20	17	15	17	3	3
Flow[2]	13	11	0	11	0	4	6	6	0	6	12	10	12	18	16	17	0	4	19	19
Channel Alteration	14	12	12	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8	11
Bottom Scouring	14	12	12	8	12	12	12	12	12	12	12	12	12	12	14	12	12	12	4	8
Pool/Riffle[2]	11	8	2	8	2	3	5	3	1	4	8	13	14	15	14	14	3	12	13	14
Bank Stability	9	5	7	1	4	9	9	9	8	9	10	10	10	10	9	10	9	10	9	10
Bank Veg. Stability	9	4	9	8	9	9	10	10	9	10	10	10	10	10	10	9	9	10	9	10
Streamside Cover	10	7	3	7	3	3	7	3	5	8	8	9	10	10	10	9	8	10	9	10
Total	115	79	82	84	65	88	96	90	85	93	93	113	118	126	123	118	83	103	92	104

Notes:

[1]The sites are listed from upstream to downstream.
[2]The definitions within the flow and pool/riffle ratio habitat parameters were modified from EPA's Habitat Assessment Field Data Sheet (EPA 1989) to be reflective of a low-gradient, low-flow stream. For example, sites with flow >0.3 cfs were defined in the highest category with possible scores ranging between 16 and 20. See Chapter 2 for further description.

TABLE 3-3
RESULTS OF ANALYSIS OF REVERSIBLE HABITAT ALTERATIONS FOR STATIONS IN EXISTING SEGMENT 4 ON WALNUT AND WOMAN CREEKS

Station No.	Location[1]	Existing Rating	Parameters Rated "Fair" or "Poor"[2]	Potential Rating	Notes
03	Below Pond A-4 on N. Walnut Creek	82	Flow, pool/riffle, streamside cover	94	Improvements due to increased flow.
05	Below Pond B-5 on S. Walnut Creek	65	Substrate, flow, pool/riffle, bank stability	67	Flow below B-5 unlikely. Some increased stability.
06	Below confluence of N. and S. Walnut Creeks	88	Flow, pool/riffle, streamside cover	96	Improvements due to increased flow.
WARI1	500 yards above pond at Indiana Street	96	Flow, pool/riffle	102	Improvements due to increased flow.
D1	Below pond on Walnut Creek at Indiana Street	90	Flow, pool/riffle, streamside cover	96	Improvements due to increased flow.
WOP01	Woman Creek below Mower Ditch	83	Flow, pool/riffle	101	Improvements due to increased flow.
WOP02	Approx. 500 feet upstream of Indiana Street	103	Flow	117	Improvements due to increased flow.

Notes:

[1]See Figure 3-1 for station locations.
[2]"Poor" or "fair" as per EPA guidance for the habitat assessment.

TABLE 3-4
BIOASSESSMENT RESULTS FOR MAY-JUNE 1991
BENTHIC SAMPLING DATA

	SW039[1]	SW033	WORI3	WORI1	SW026	WOPO1	WOPO2	WARI1
METRIC VALUES								
Taxa Richness	20	19	29	25	15	12	6	10
Hilsenhoff Biotic Index	4.21	6.52	5.49	5.27	5.60	5.61	5.86	4.65
Ratio of Scrapers/Filtering Collectors	0.07	0.05	0.21	0.007	0	0.09	0	0
Ratio of EPT/Chironomid Abundances	0.56	0.18	2.7	0.29	0.12	0.037	0.89	0
Contribution of Dominant Taxon	0.49	0.53	0.32	0.88	0.34	0.56	0.56	0.20
EPT Index	4	6	11	10	5	1	1	0
Community Loss Index	1	0.33	0.34	0.32	0.60	1	2.83	1.5
BIOLOGICAL CONDITION SCORES								
Taxa Richness	6	6	6	6	4	4	0	4
Hilsenhoff Biotic Index	6	2	4	4	4	4	4	6
Ratio of Scrapers/Filtering Collectors	6	6	6	0	0	6	0	0
Ratio of EPT/Chironomid Abundances	6	2	6	4	0	0	6	0
Contribution of Dominant Taxon	0	0	2	0	2	0	0	4
EPT Index	6	6	6	6	0	0	6	0
Community Loss Index	6	6	6	6	4	4	2	2
Total Biological Condition Score Relative to Reference Station	100%	78%	100%	72%	39%	50%	50%	44%

Notes:
[1]SW039 is the reference station

65

TABLE 3-5
LIST OF SPECIES OF FISH COLLECTED IN WALNUT, WOMAN, AND BIG DRY CREEKS

	So. Walnut Creek(1) (in ponds)	Walnut Creek(1) (below ponds)	SW03 Walnut Creek(3)	SW001/SW002 Woman Creek(2)	Woman Creek(1)	Big Dry Creek(2) (below confluence with Walnut)	Big Dry Creek(3) (above confluence with Walnut)
No. of Stations	5	2	1	2	9	4	2
Classification	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2	Aquatic Life Warm 2
Ammonia Standard	0.1 mg/L(ch)	0.1 mg/L(ch)	0.1 mg/L(ch)	0.1 mg/L(ch)	0.1 mg/L(ch)	none	none
Species							
Longnose Sucker							X
Creek Chub					X	X	X
Longnose Dace						X	X
White Sucker				X	X	X	X
Johnny Darter							X
Green Sunfish				X	X	X	X
Small Mouth Bass							X
Fathead Minnow	X	X	X	X	X	X	X
Large Mouth Bass				X	X		
Stoneroller					X		
Golden Shiner				X	X		
Total No. of Species	1	1	1	5	7	5	8

Notes:
(1)Data from DOE, 1992, *Baseline Biological Characterization of the Terrestrial and Aquatic Habitats at the Rocky Flats Plant.*
(2)Data from Limited Fish Survey Data from Colorado Division of Wildlife Stream Surveys (1992-1993, unpublished).
(3)Data from sampling in summer of 1991 (EG&G).

APPENDIX A
WATERSHED AND FLOW CHARACTERISTICS OF WALNUT CREEK AND WOMAN CREEK

The watersheds pertinent to this study include Walnut Creek and its tributaries above Great Western Reservoir, and Woman Creek and its tributaries upstream from where Woman Creek crosses Indiana Street. A map of these watersheds, the corresponding flow paths, and other important surface water features are shown in Figure A-1. This appendix discusses surface water hydrology for each of the watersheds and stream segments. It also describes the effect of RFETS operational activities and other diversions within these watersheds on the flow regime of each segment. For comparison purposes, hydrologic aspects of Walnut Creek below Great Western Reservoir are also described. A routing schematic for flow through the detention ponds is shown in Figure A-2.

A.1 GENERAL DESCRIPTION OF THE WALNUT CREEK WATERSHED

The Walnut Creek drainage basin extends eastward from the base of the foothills near the mouth of Coal Creek Canyon through RFETS and Great Western Reservoir to a confluence with Big Dry Creek approximately five miles east of RFETS. The subbasin of particular interest to this study is the basin area tributary to Great Western Reservoir and west of Indiana Street. This subbasin comprises approximately 2,376 acres (Wright Water Engineers, Inc. [WWE] 1992). While the majority of this watershed consists of undeveloped land, most of the 400-acre RFETS Industrial Area (IA) is tributary to this subbasin.

Surface water features within this subbasin include several small unnamed tributaries that drain undeveloped portions of the north and east Buffer Zone, an unnamed tributary which contains the existing RFETS landfill and landfill pond, the RFETS A- and B-series ponds, and the main tributaries of North and South Walnut Creeks, which receive a majority of their water from runoff from the RFETS IA. These two tributaries join to form the main stem of Walnut Creek, just below the A- and B-series ponds and approximately 2,500 feet west of Indiana Street.

The topographic and hydrologic characteristics of the subbasin vary considerably throughout its length and, from a hydrologic perspective, can be divided into an upper, central, and lower portion. The upper or western portion of the subbasin, from the mouth of Coal Creek Canyon to approximately the western edge of the IA is relatively flat, sloping approximately 2 percent to the east. There are no defined stream channels in this portion of the subbasin. Soils are characterized by a high infiltration rate (6.0 inches per hour initial infiltration rate). The central portion of the subbasin, containing North and South Walnut Creeks, the RFETS A- and B-series detention ponds, and the Landfill Pond tributary, consists of gullies with up to 20 percent sideslopes and 4 percent channel slopes leading into the tributaries. Soils in this region have a relatively low initial infiltration rate of 1.0 inch per hour. The lower part of the subbasin, starting just downstream of the detention ponds and extending to Indiana Street, consists of broader valleys with about 5 percent sideslopes and 2 percent channel slope. The soils in this reach have low to moderate initial infiltration rates of 1.0 to 3.0 inches per hour (WWE 1992). Topographically, Walnut Creek below Great Western Reservoir is very similar in terms of sideslopes and channel slope to that portion of Walnut Creek between the RFETS detention ponds and Indiana Street.

A.1.1 Walnut Creek Flow Paths

In an effort to control the quality and quantity of water both entering and leaving RFETS, a number of hydrologic modifications to Walnut Creek have been implemented over the years. These include the McKay Diversion constructed in 1978; the A- and B-series drainage ponds, with various construction dates from 1952 to 1979; and the Broomfield Diversion Ditch, constructed in 1989. Irrigation flows and stormwater runoff in the upper portions of the basin are permanently diverted by the McKay Diversion structure upstream of the IA and are routed north of the Landfill Pond and A-series ponds via the McKay Ditch. Flows in the McKay Ditch eventually re-enter lower Walnut Creek approximately 1,750 feet upstream of Indiana Street. Since the fall of 1989, all flows in lower Walnut Creek on RFETS property have been diverted from Great Western Reservoir by a structure just east of Indiana Street and routed around Great Western Reservoir via the Broomfield Diversion Ditch, re-entering lower Walnut Creek (Segment 1 of Big Dry Creek) below the dam for Great Western Reservoir.

Flows in the upper and central parts of the Walnut Creek basin on RFETS property are dominated by stormwater runoff following precipitation events. In the upper basin, runoff from most storm events infiltrates the soil very rapidly resulting in very little runoff reaching lower Walnut Creek on a routine basis. However, flow through the McKay Ditch during spring runoff is relatively common and major storm events have resulted in flows at estimated rates in excess of 20 cubic feet per second (cfs) (Pettis 1995). Routine irrigation flows in McKay Ditch have not occurred since 1989, although the city of Broomfield maintains upstream water rights which could result in routine flows through this ditch in the future (Schnoor 1995). In the central part of the subbasin, the majority of streamflows in North and South Walnut Creeks comprise stormwater discharges from impervious areas of the RFETS IA. Groundwater return flows also occur in this section of the subbasin, resulting in a small baseflow that is maintained in North and South Walnut Creeks just above the ponds most times of the year.

In the lower part of the subbasin (e.g., between Pond A-4 and Indiana Street), streamflows are heavily dominated by releases from Pond A-4. Due to current operational practices involving routine retention of stormwater flows, approximately the first 2,000 feet of stream below Pond A-4 remains essentially dry, even during spring runoff, except when releases are occurring from Pond A-4. In addition, since Pond B-5 no longer discharges directly to South Walnut Creek, South Walnut Creek below Pond B-5 is essentially dry during all times of the year except during and immediately following storm events. Further downstream, beginning at a point approximately where the McKay Ditch re-enters Walnut Creek, groundwater exfiltration creates damp areas and small pools within depressions in the stream channel most times of the year, although a constant baseflow has not been observed except during spring and early summer.

Walnut Creek below Great Western Reservoir receives water from a variety of sources. In addition to receiving discharges from RFETS (via the Broomfield Diversion Ditch), this section of Walnut Creek receives intermittent high volume flows from the Church Ditch and infrequent releases from Great Western Reservoir itself. A small but constant baseflow is also maintained by discharges from an underdrain in the downstream toe of the Great Western Reservoir dam.

A.1.2 Walnut Creek Stream Segment Designations

Currently, the intermittent streams within the Walnut Creek basin are designated as either Segment 4 or Segment 5 of Big Dry Creek, depending on location with respect to the RFETS drainage ponds. As shown in Figure 1-1, lower portions of North and South Walnut Creeks below Ponds A-4 and B-5, two unnamed dry tributaries to the north of North Walnut Creek, and the upper reaches of North and South Walnut Creeks to the west of the RFETS IA are all classified as Segment 4. The four ponds on North Walnut Creek (Ponds A-1, A-2, A-3, and A-

4), the five ponds on South Walnut Creek (Ponds B-1, B-2, B-3, B-4, and B-5), and all portions of North and South Walnut Creek tributary to these ponds are classified as Segment 5. Great Western Reservoir, a drinking water supply for the city of Broomfield, is designated as Segment 3 of Big Dry Creek. Below Great Western Reservoir, Walnut Creek is designated as Segment 1.

A.2 GENERAL DESCRIPTION OF THE WOMAN CREEK WATERSHED

The Woman Creek drainage basin extends eastward from the base of the foothills near the mouth of Coal Creek Canyon to Standley Lake. The portion of the basin from the headwaters to Indiana Street contains approximately 2,884 acres. Except for the southern portion of the IA, the watershed contains mostly undeveloped land. Major drainages include the tributaries of North and South Woman Creeks which converge to form Woman Creek just west of the IA and Antelope Springs Creek which enters Woman Creek approximately 3,500 feet below this convergence (EG&G 1994b).

A number of irrigation ditches potentially affect the flow regime of Woman Creek. To the west, the Kinnear Ditch diverts water from Coal Creek and routes this water into and through North Woman Creek. To the south, Smart Ditch 2 can divert water from Smart Ditch 1 into South Woman Creek. Smart Ditch 1 carries water released from Rocky Flats Lake to an unnamed natural drainageway south of Woman Creek that is nominally tributary to lower Woman Creek. However, this water is continuously diverted to Ponds D-1 and D-2 which are on-site but are privately operated irrigation ponds used exclusively for off-site agricultural purposes. To the east of Pond C-2, Mower Ditch diverts water from lower Woman Creek off-site to Mower Reservoir, which is also used for agricultural purposes.

The basin is similar to Walnut Creek in that the uplands are relatively flat, there is a central portion of steeper gullies draining to Woman Creek, and a lower portion characterized by broader valleys leading into Standley Lake. As with Walnut Creek, the soil infiltration characteristics vary according to topography. The upland soils have a high infiltration rate, the steep gullied area a low rate, and the broader valleys a low to moderate rate.

A.2.1 Woman Creek Flow Paths

Flows from Kinnear Ditch, Smart Ditch 2, North and South Woman Creeks, and Antelope Springs Creek converge and flow through Pond C-1, a small on-channel pond located in the central portion of the drainage. Further downstream, water in Woman Creek is rerouted around Pond C-2 by a permanent concrete diversion structure such that Woman Creek flows do not enter this pond. Since 1991, a permanent diversion structure downstream of Pond C-2 has diverted all flows less than one foot in depth away from the lower portion of Woman Creek and into the Mower Ditch.

A.2.2 Woman Creek Stream Segment Designations

All portions of Woman Creek on RFETS property fall within Segment 4 of Big Dry Creek (South Platte River Basin). Pond C-2, the off-channel pond that collects stormwater runoff from southern portions of the RFETS developed area via the South Interceptor Ditch (SID), is classified as part of Segment 5 of Big Dry Creek. Standley Lake is designated as Segment 2 of Big Dry Creek and provides drinking water to the municipalities of Westminster, Thornton, Northglenn, and others. Mower Ditch and Mower Reservoir have no segment designation.

A.3 DETENTION POND FUNCTIONS AND OPERATIONS

The hydrology of lower Walnut Creek, and to a lesser extent Woman Creek, is influenced by the operation of the upstream detention ponds. The A-series ponds (A-1, A-2, A-3, and A-4) lie within the natural channel of North Walnut Creek northeast of the IA. Ponds A-1 and A-2 are reserved for the purpose of containing potential spills to surface water at the site and, in terms of surface flows, are hydrologically isolated from the normal flow path of North Walnut Creek by a diversion dam immediately upstream of Pond A-1. This diversion dam has a double gate structure that is normally set so that all routine stormwater flows and North Walnut Creek baseflow are diverted into a bypass pipe which carries the water around Ponds A-1 and A-2 to Pond A-3. Pond A-3 receives all runoff generated from the northern portion of the IA and the undeveloped area (Buffer Zone) immediately north of the IA as well as areas in the Buffer Zone immediately around the ponds. Water is held in Pond A-3 until sufficient volume has accumulated, and then batch-released to Pond A-4 using the existing bottom discharge outlet works.

The B-series ponds (B-1 through B-5) lie within the natural channel of South Walnut Creek just east of the IA. Similar to Ponds A-1 and A-2, Ponds B-1 and B-2 are reserved for the purpose of containing potential spills to surface water from the site and are isolated from the normal surface water flow path of South Walnut Creek. Similar to North Walnut Creek, a gated diversion dam exists immediately above Pond B-1, which diverts South Walnut Creek baseflow and stormwater into a bypass pipe that outfalls to Pond B-4. Pond B-4 has virtually no storage capacity and passes this water directly to Pond B-5. Ponds B-4 and B-5 receive the majority of stormwater runoff from the RFETS IA.

Treated effluent from the RFETS WWTP is piped directly to Pond B-3. Water in Pond B-3 is released daily during daylight hours to Pond B-4 via a manually-controlled outlet valve, and subsequently flows through Pond B-4 into Pond B-5.

Other than localized runoff, Pond C-2 only receives stormwater flows from a small portion of the Woman Creek drainage basin which is now captured by the SID. This ditch intercepts overland runoff from the southern portion of the IA, some footing drain discharges, primarily from Building 460, and treated effluent from the Operable Unit (OU) 1 groundwater treatment system. The SID routes these waters to Pond C-2, which is considered an off-channel pond within the Woman Creek watershed. The SID, Pond C-2, and the Woman Creek diversion structure around Pond C-2 were all constructed in 1979.

Prior to 1990, water was discharged from Pond B-5 directly to South Walnut Creek. Beginning in September 1990, Pond B-5 has been transferred via pump and pipeline to Pond A-4 in order to consolidate discharge operations at Pond A-4. All water in the A- and B-drainages is currently discharged to Walnut Creek and off-site through Pond A-4. These discharges typically occur approximately every two to three months over a ten to fifteen day period, except during late winter and spring when releases occur more frequently, or for a longer duration in response to increased runoff.

From 1980 to 1990, water accumulating in Pond C-2 following storm events was routinely released directly to Woman Creek after a short settling period and following sampling and analysis of water quality. Since 1990, and based on a continuing agreement with the city of Westminster and CDPHE, water from Pond C-2 has been transferred via pipeline to the

Broomfield Diversion Ditch, where it eventually ends up in lower Walnut Creek below Great Western Reservoir.

Since Pond C-2 accumulates far less water than other ponds, and generally discharges only two or three times per year, diversion of Pond C-2 water to the Broomfield Diversion Ditch has not had a major effect on the flow regime of lower Woman Creek. Of far greater impact to the flow regime of lower Woman Creek is the current diversion practices of the Mower Ditch discussed previously. Due to this diversion, baseflow in lower Woman Creek is now zero or near zero for most of the year.

A.4 FLOW DATA

From an aquatic life standpoint, the ability of a stream segment to support and maintain viable aquatic life communities is highly dependent on the frequency and volume of water that occurs in the segment. In particular, the presence of a continuous baseflow is important for supporting aquatic life on a long-term basis.

Reliable flow data for Woman and Walnut Creeks has been collected since the spring of 1991 as part of the Event Related Surface Water Monitoring Program. This program includes continuous flow monitoring at 20 of the 21 gaging stations shown on Figure A-3 and designated as "GS." The only station not monitored is GS08 which does not receive flow due to transfer of water from Pond B-5 to A-4 via pipeline. Data collected under this program are summarized in a series of reports entitled, *Event Related Surface Water Monitoring Report, Rocky Flats Plant, Water Years 1991 and 1992* (EG&G 1993a) and *Event Related Surface Water Monitoring Report, Rocky Flats Environmental Technology Site, Water Year 1993* (EG&G 1994a). Flow data was also collected at additional stations during a 15-month period from October 1991 through December 1992 as part of the *Stormwater NPDES Permit Application Monitoring Program, Rocky Flats Plant Site* (EG&G 1993b). These stations are also shown on Figure A-3 and are designated as "SW." Available data for total monthly yield and monthly mean, maximum, and minimum flow for selected gaging stations on Woman and Walnut Creeks for water years 1991, 1992, 1993, and 1994 are provided in Tables A-1 and A-2.

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A.4.1 Walnut Creek Flows

Seven gaging stations monitor flows on Walnut Creek from the western edge of the IA to Indiana Street. These stations include GS10 and GS09 on South Walnut Creek; GS13, GS12, and GS11 on North Walnut Creek; and GS03 located on the main stem of Walnut Creek just downstream of the small Walnut and Indiana pond. The upper reach is not currently monitored under the Event Related Program; however, flow data is available for water year 1992 from SW118. Mean daily discharge for water years 1991 through 1994 for GS03 and GS11 stations are shown in Figure A-4.

The 1992 record from SW118 indicates that the upper reach of North Walnut Creek is dry except during periods of precipitation runoff (EG&G 1994b). Further downstream on North Walnut Creek (at GS13) flows are also dominated by stormwater runoff from the IA; however, GS13 also receives groundwater exfiltration and has a low but measurable baseflow year-round. In contrast to North Walnut Creek (as monitored by GS13), South Walnut Creek (as monitored by GS10) is often dry during the summer months and has a lower baseflow than North Walnut Creek at other times of the year (EG&G 1994a).

Flow in the main stem of Walnut Creek below Pond A-4 is dominated by discharges from Pond A-4 which typically occur every two to three months during the summer, fall, and winter and approximately every month during late winter/early spring in response to spring storms and snowmelt conditions. As seen by the hydrographs from GS11 and GS03 (Figure A-4), flow in the lower reach of Walnut Creek is characterized by large peaks corresponding to storm events or discharges from Pond A-4 followed by essentially dry conditions. Very little groundwater seepage occurs in Walnut Creek below Pond A-4. The dams for the terminal Ponds A-4 and B-5 on North and South Walnut Creeks are constructed with impermeable cores which extend to bedrock and, therefore, intercept and retain upstream groundwater moving through the alluvial material, and similarly prevent significant seepage through or under the ponds. Based on field observations made in September 1994, baseflow immediately downstream from the ponds is negligible, although further downstream groundwater seepage provided standing pools of water and some very limited baseflow closer to Indiana Street. On an annual basis, lower Walnut Creek between GS11 to GS03 loses water to the valley fill alluvium year-round, with calculated losses ranging from 8 to 41 percent (EG&G 1994b).

A.4.2 Woman Creek Flows

Ten gaging stations measure flows in the Woman Creek drainage. These stations include GS05, GS06, and GS18, which monitor flows in the upper reaches of the basin; GS16, GS17, and GS07, which monitor the central portion of the basin; and stations GS14, GS01, and GS02, which monitor the lower reach. GS15 monitors flows on Smart Ditch 1 at the concrete splitter box which routes water away from Woman Creek to the so-called D-ponds. Mean daily discharges for water years 1991, 1992, 1993, and 1994 for gaging stations GS01, GS02, and GS07 are presented graphically in Figure A-5.

Flow records indicate that the majority of flow in the headwaters of Woman Creek results from precipitation runoff supplemented by irrigation flows, groundwater seepage, and presumed leakage from the South Boulder diversion canal (EG&G 1994b). GS05 and GS06 are dry most of the year except during precipitation events or when irrigation diversions through the Kinnear Ditch or Smart Ditch 2 are occurring. Based on data from water year 1993, there was a significant loss of flow to the shallow groundwater in the reach between the North/South Woman Creek confluence and GS18 except during the early spring when a small gain occurred. Between July 1, 1993 and September 30, 1993, 96 percent to 99 percent of the flow was lost in this reach resulting in a lack of substantial baseflow at GS18 (EG&G 1994a).

Precipitation runoff and the perennially flowing Antelope Springs account for the majority of flow in the central portion of Woman Creek. In the summer and fall, Antelope Springs contributes nearly 100 percent of the baseflow to this reach. However, losses between Antelope Springs and GS17 result in a lack of substantial flow at GS17 or GS07 much of the year (EG&G 1994a).

Flows in lower Woman Creek (e.g., below the Mower Ditch diversion) result primarily from storm events and groundwater seepage. Except for brief periods during late winter and early spring runoff, continuous flow is not recorded at GS01 due to the current practice of diverting all upstream flows less than one foot in depth to the Mower Ditch. Intermittent low flows that do occur during summer and fall are due to runoff from the local basin, seepage, or interflow from Woman Creek and the Mower Ditch, and potentially from seepage or interflow from Smart Ditch located to the south (EG&G 1994b).

A.4.3 Pond Water Discharges

Pond level and discharge data for Ponds A-4, B-5, and C-2 provide additional information relevant to the effect of pond operational practices on the downstream flow regimes of Walnut and Woman Creeks. Pond level fluctuations under the current batch release operational mode for Ponds A-4, B-5, and C-2 are shown in Figure A-6. Pond B-5 cycles between fill mode and transfer (discharge) mode on a relatively continuous basis, due in large part to constant inflows from the RFETS WWTP. Pond B-5 operations are characterized by moderately long fill periods averaging 25 days, followed by moderately short discharge periods of 10 to 15 days. Over the most recent 3-year period of record, Pond B-5 discharged (transferred) 349 days, or 32 percent of the time. Conversely, Pond A-4 is characterized by extended hold periods, preceded by relatively short fill periods, and followed by relatively short discharge periods. Over the most recent 3-year period of record for Pond A-4, discharges occurred on 335 days, or 31 percent of the time. Discharge rates for Pond A-4 are approximately double the transfer rate for Pond B-5. At Pond C-2, due to much lower inflows, the ratio of fill and hold time versus discharge time is much greater. Pond C-2 only discharged 33 days, less than 5 percent of the time over the 1992/1993 period of record. Pond C-2 did not discharge at all during water year 1994.

The impacts of these operational practices on the downstream flow regimes of Walnut and Woman Creek are quite different. For lower Walnut Creek, the operational practice of transferring water from B-5 to A-4, rather than discharging this water continuously has significantly reduced the number of days in which water occurs in the creek. In addition, the intermittent discharge of Pond A-4 is characterized by relatively high flow rates (in excess of 1,3000 gpm) over short (approximately two weeks) periods of time, followed by essentially dry conditions. Based on the annual volume of water passing through Pond A-4 (approximately 129 Mgal annually), a constant minimum flow of approximately 0.15 cfs (54 gpm) could be maintained in lower Walnut Creek should this be desired.

At Pond C-2, the total number of discharge days and the total volume of water received in Pond C-2 (approximately 11 Mgal annually) are much lower. Water detained in Pond C-2 could not provide a continuous flow to lower Woman Creek, even if this were desired. Thus, the operational practices of holding water in Pond C-2 or transferring Pond C-2 water to the Broomfield Diversion Ditch have no significant impact on the flow regime in lower Woman Creek.

Changes to pond operational practices are proposed in the *Final Draft Pond Water Management Interim Measures/Interim Remedial Action Decision Document* which would result in releases to lower Walnut Creek from Ponds A-4 and/or B-5 on a more frequent basis and at lower flow rates. These operational changes have the potential to improve the overall flow regime of Walnut Creek below Pond A-4 and have potential beneficial impacts on the downstream aquatic communities and riparian habitats. However, the acceptability of these operational changes to regulatory personnel or downstream municipalities is unknown at this time, and no schedule has been established for implementing these changes. Irrespective of future changes, the flow regimes of Walnut and Woman Creeks will remain substantially different in terms of flow and the impact of human activities for the foreseeable future.

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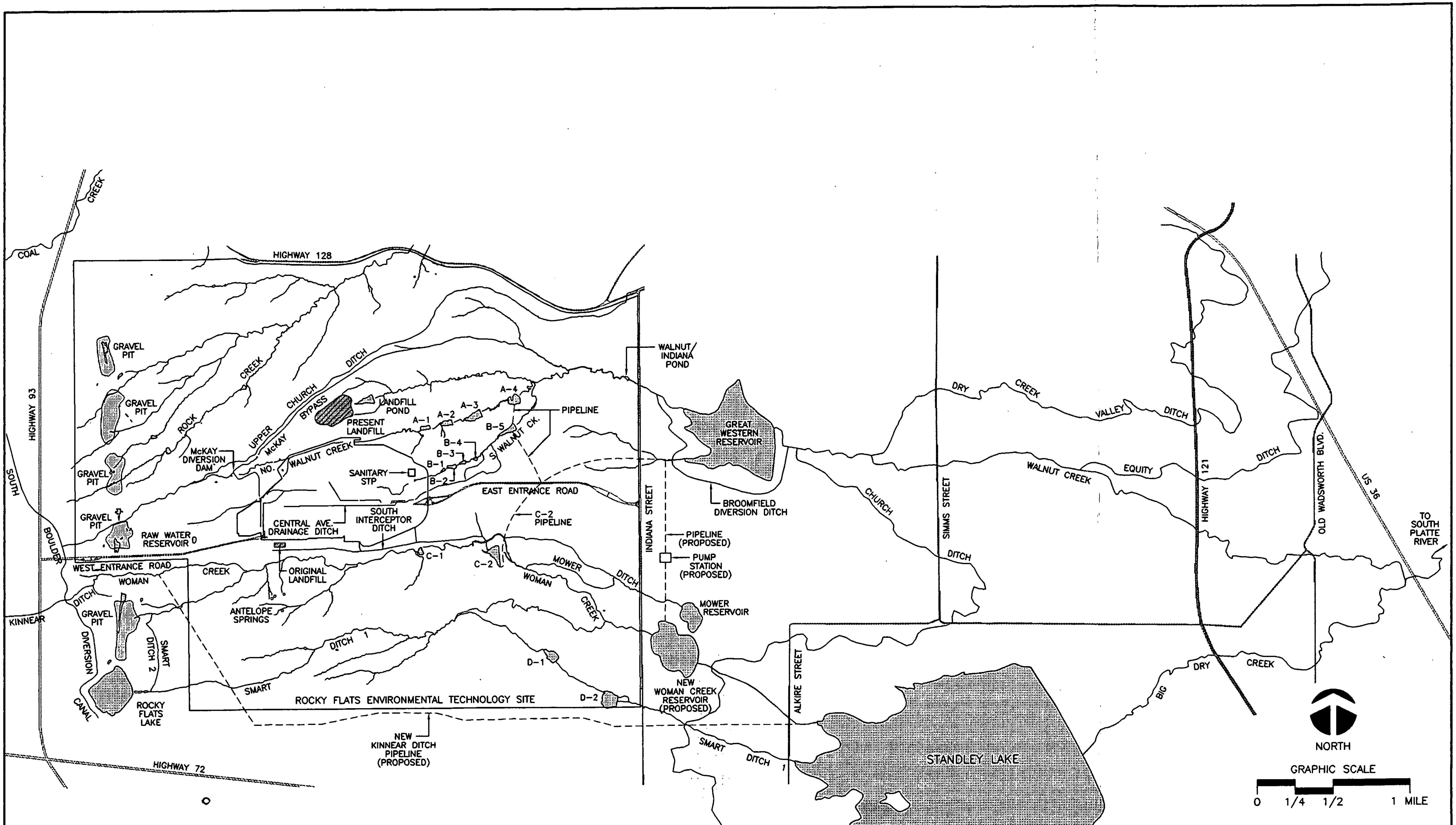

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DRAWN BY	KAL	APPROVED	–
DATE	FEB 21, 1995	SCALE	1"=3200'

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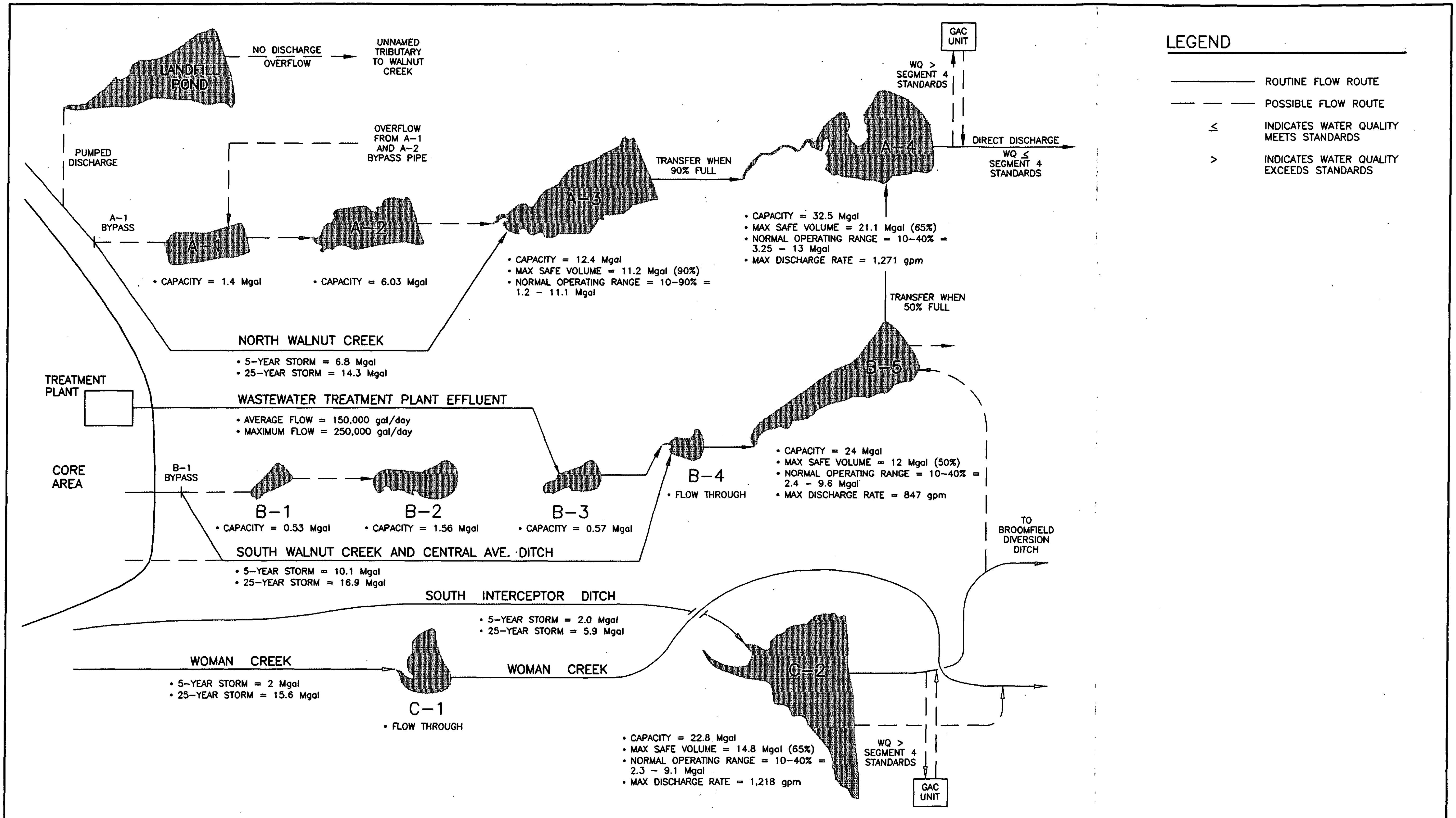
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

FIGURE A-1
UPSTREAM AND DOWNSTREAM SURFACE WATER FEATURES



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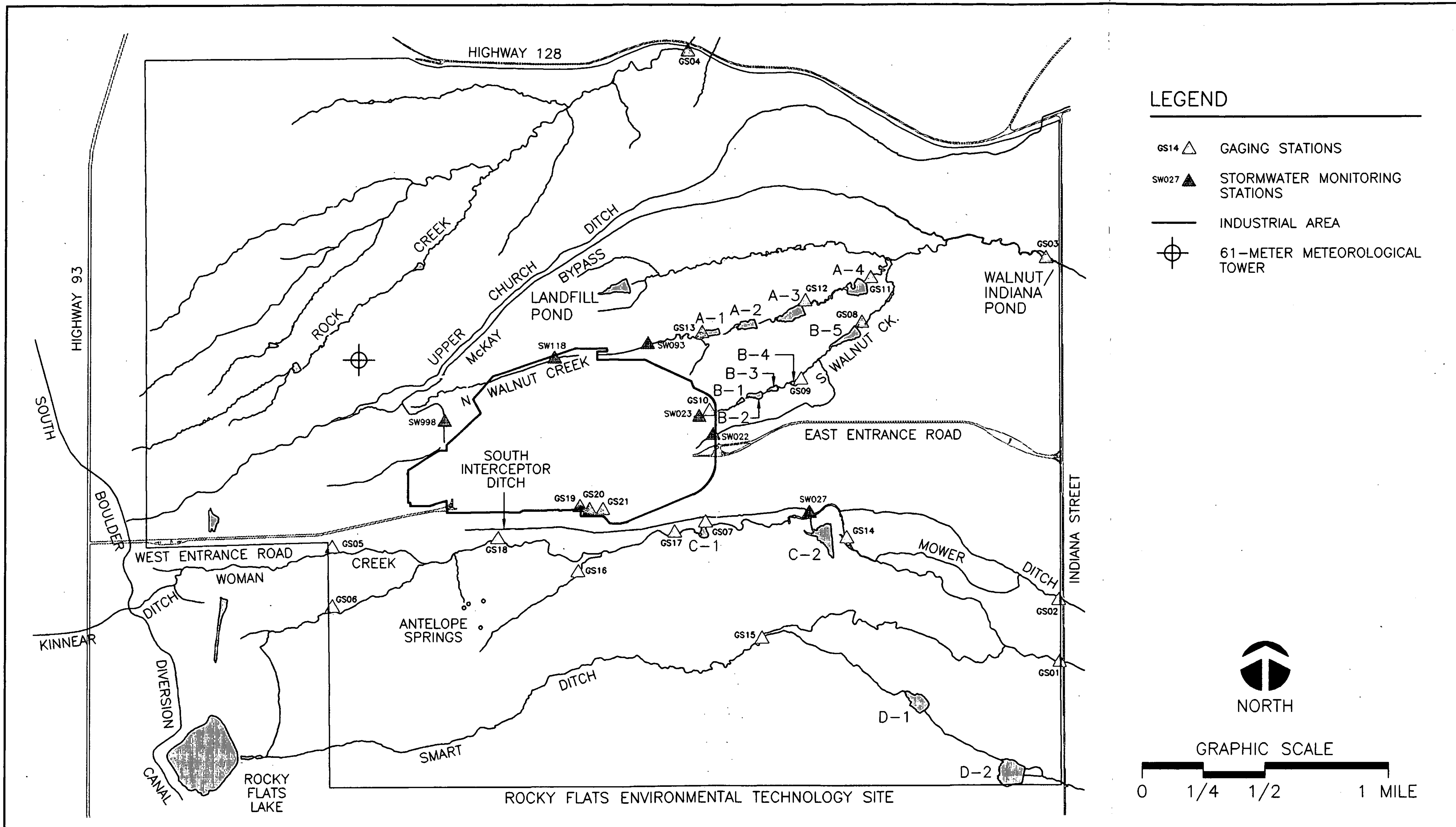
DATE	FEB. 21, 1995	SCALE	NOT TO SCALE

PREPARED FOR

U.S. DEPARTMENT OF ENERGY

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

FIGURE A-2
ROUTING SCHEMATIC FOR ROUTINE POND OPERATIONS



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ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

FIGURE A-3
GAGING STATIONS AND STORMWATER MONITORING LOCATIONS

Figure A-4
Comparison of Upstream and Downstream Woman Creek Flows
(Water Years 1991 - 1994)

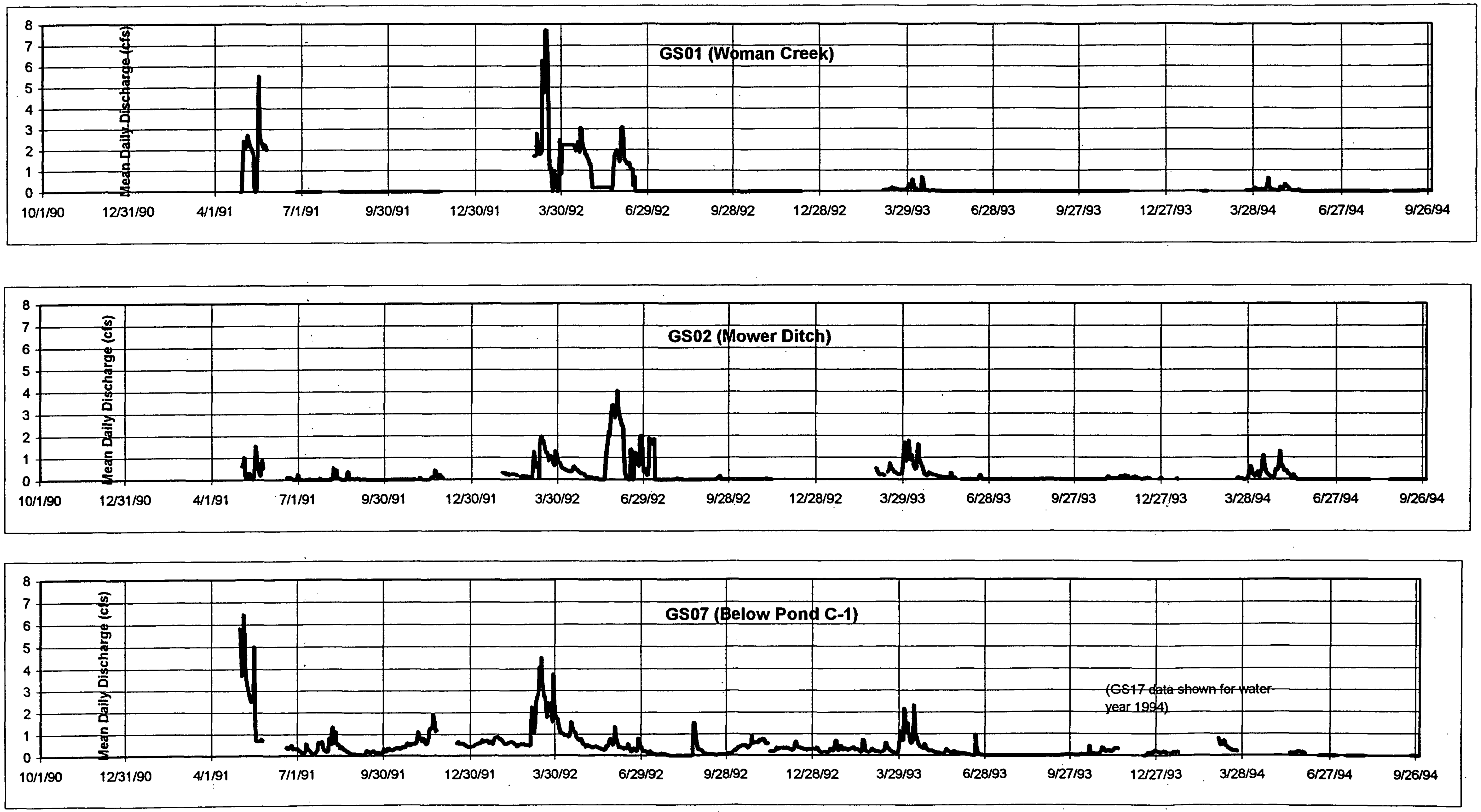
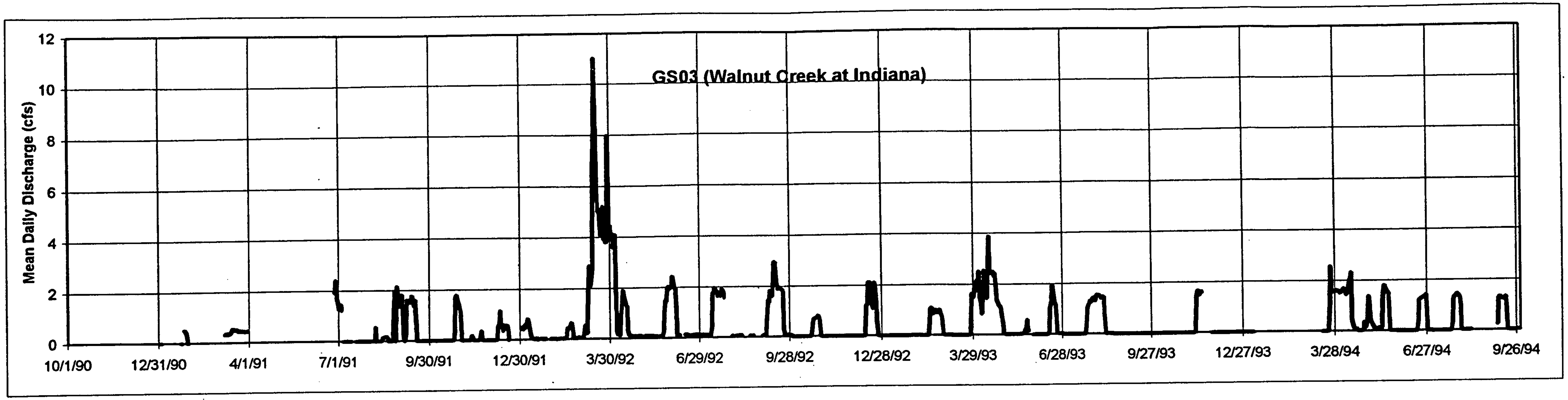


Figure A-5
Comparison of A-4 Discharges with Off-Site Walnut Creek Flows
(Water Years 1991-1994)



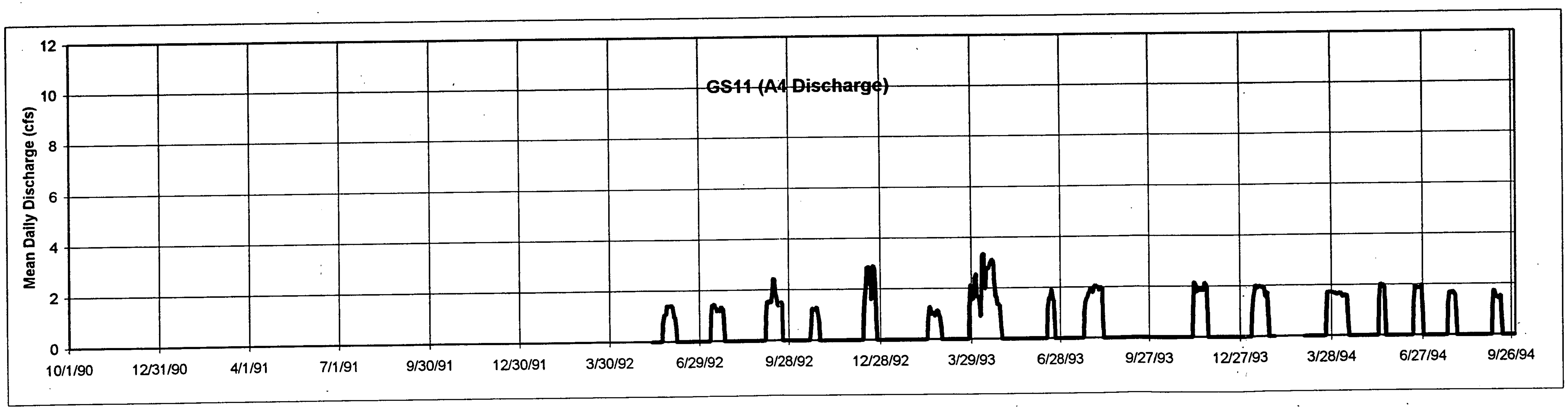


Figure A-6
Pond Level Fluctuation Under Batch Mode Operations
10/1/90 Through 9/30/94

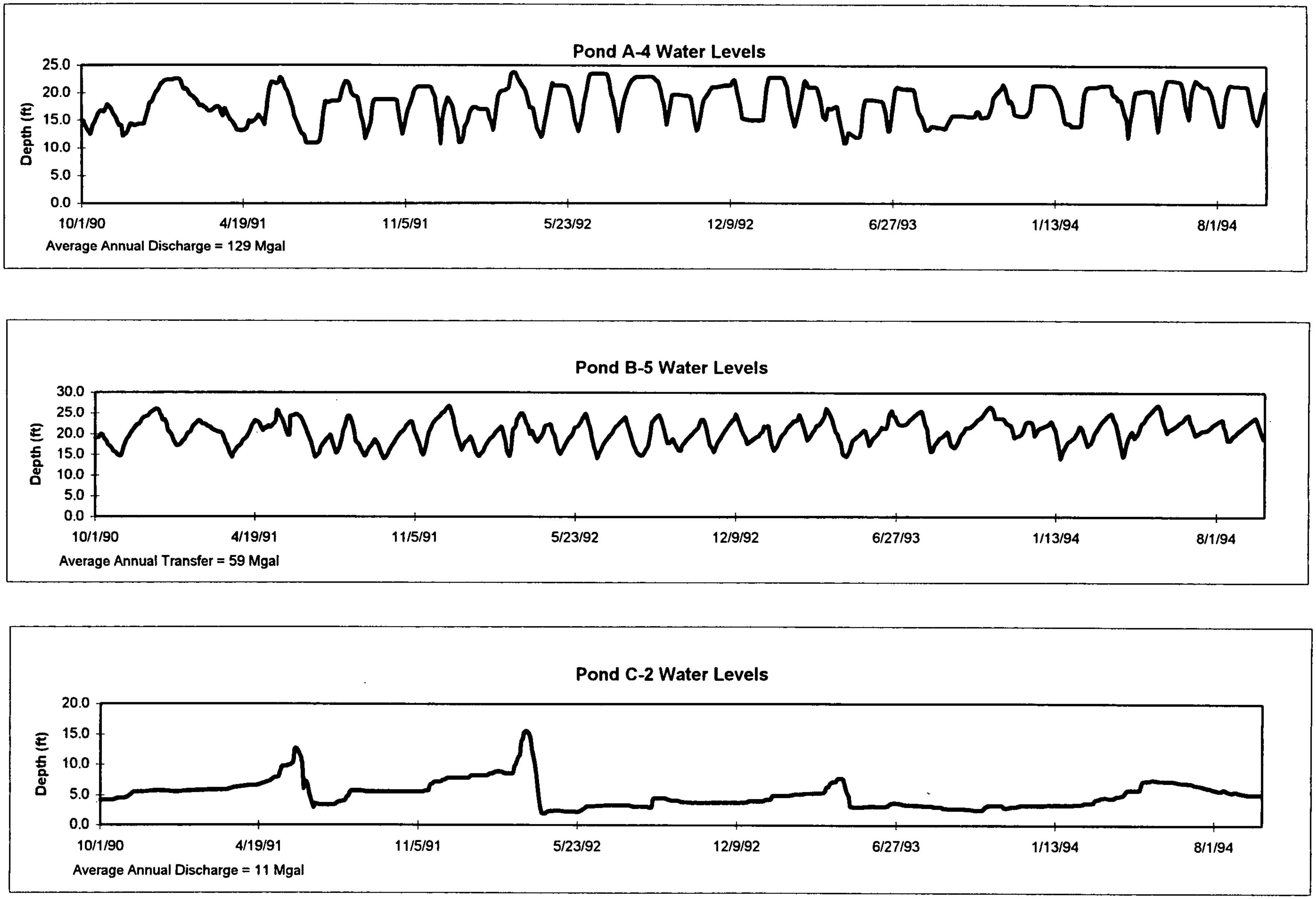


Table A-1
Selected Gaging Station Records for Woman Creek

1991 Water Year

	Woman Creek at Indiana Street				Mower Ditch at Indiana Street				Woman Creek below Pond C-1			
	GS01				GS02				GS07			
	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)
Oct												
Nov												
Dec												
Jan	NA	NR	NR	NR	NA	NR	NR	NR	NA	NR	NR	NR
Feb	NA	NR	NR	NR	NA	NR	NR	NR	NA	NR	NR	NR
Mar	NA	NR	NR	NR	NA	NR	NR	NR	NA	NR	NR	NR
Apr	30.16	0.51	0.00	1.52	NA	NR	NR	NR	NA	NR	NR	NR
May	127.85	2.08	0.00	5.55	27.33	0.44	0.03	1.57	147.74	2.40	0.70	6.46
Jun	13.82	0.23	0.00	1.61	28.52	0.48	0.00	2.51	44.84	0.75	0.32	3.85
Jul	0.11	0.00	0.00	0.01	0.93	0.02	0.00	0.11	17.41	0.28	0.06	0.69
Aug	0.00	0.00	0.00	0.00	6.07	0.10	0.00	0.56	26.60	0.43	0.06	1.36
Sep	0.00	0.00	0.00	0.00	0.59	0.01	0.00	0.07	7.74	0.13	0.03	0.29

1992 Water Year

	Woman Creek at Indiana Street				Mower Ditch at Indiana Street				Woman Creek Below Pond C-1			
	GS01				GS02				GS07			
	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)
Oct	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.02	23.60	0.38	0.19	0.59
Nov	0.00	0.00	0.00	0.00	5.04	0.08	0.00	0.45	57.14	0.96	0.54	1.95
Dec	NA	NR	NR	NR	NA	NR	NR	NR	32.01	0.52	0.41	0.66
Jan	NA	NR	NR	NR	NA	NR	NR	NR	40.45	0.66	0.43	0.90
Feb	NA	NR	NR	NR	12.25	0.21	0.11	0.34	31.52	0.57	0.43	0.78
Mar	145.96	2.37	0.00	7.73	62.01	1.01	0.08	1.97	140.61	2.29	0.47	4.52
Apr	124.32	2.09	1.25	3.04	24.56	0.41	0.14	0.79	59.76	1.00	0.52	1.77
May	36.35	0.59	0.09	2.00	62.37	1.01	0.00	3.41	27.76	0.45	0.27	0.78
Jun	44.51	0.75	0.00	3.10	75.57	1.27	0.00	4.06	25.72	0.43	0.19	1.35
Jul	0.00	0.00	0.00	0.00	24.62	0.40	0.00	1.90	6.17	0.10	0.00	0.22
Aug	0.00	0.00	0.00	0.00	0.57	0.01	0.00	0.07	12.05	0.20	0.00	1.54
Sep	0.03	0.00	0.00	0.00	1.05	0.02	0.00	0.18	4.61	0.08	0.02	0.27

1993 Water Year

	Woman Creek at Indiana Street				Mower Ditch at Indiana Street				Woman Creek Below Pond C-1			
	GS01				GS02				GS07			
	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)
Oct	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.02	24.73	0.40	0.09	0.92
Nov	0.00	0.00	0.00	0.00	0.54	0.01	0.00	0.03	26.69	0.45	0.19	0.79
Dec	NA	NR	NR	NR	NA	NR	NR	NR	20.47	0.33	0.25	0.66
Jan	NA	NR	NR	NR	NA	NR	NR	NR	16.96	0.28	0.13	0.70
Feb	NA	NR	NR	NR	NA	NR	NR	NR	16.17	0.29	0.15	0.73
Mar	6.40	0.10	0.06	0.35	27.06	0.44	0.19	1.71	17.84	0.29	0.10	1.16
Apr	7.78	0.13	0.01	0.69	40.63	0.68	0.17	1.78	48.52	0.82	0.20	2.35
May	0.11	0.00	0.00	0.01	6.64	0.11	0.00	0.31	9.37	0.15	0.08	0.30
Jun	0.00	0.00	0.00	0.00	1.37	0.02	0.00	0.21	5.41	0.09	0.00	0.98
Jul	0.00	0.00	0.00	0.00	0.44	0.01	0.00	0.02	0.02	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00	0.36	0.01	0.00	0.02	0.01	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.00	0.52	0.01	0.00	0.02	0.91	0.02	0.00	0.06

1994 Water Year

	Woman Creek at Indiana Street				Mower Ditch at Indiana Street				Woman Creek Above C-1			
	GS01				GS02				GS17(see note)			
	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)
Oct	0.00	0.00	0.00	0.00	0.38	0.01	0.00	0.04	6.19	0.10	0.02	0.46
Nov	0.00	0.00	0.00	0.00	6.26	0.11	0.03	0.21	16.08	0.27	0.18	0.37
Dec	NA	NR	NR	NR	3.78	0.06	0.03	0.10	9.92	0.16	0.06	0.25
Jan	NA	NR	NR	NR	2.33	0.04	0.03	0.06	9.05	0.15	0.10	0.21
Feb	0.00	0.00	0.00	0.00	NA	NR	NR	NR	NA	NR	NR	NR
Mar	4.10	0.07	0.02	0.18	7.81	0.13	0.00	0.61	21.86	0.36	0.17	0.71
Apr	7.82	0.13	0.02	0.65	22.30	0.37	0.09	1.30	51.23	0.86	0.27	2.53
May	2.68	0.04	0.00	0.25	10.39	0.17	0.00	0.80	24.68	0.40	0.07	1.40
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.02	0.00	0.12
Jul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.03

NR = no record
NA = not applicable
Note: No GS07 records available for water year 1994. GS17 records (above Pond C-1) substituted.

Table A-2
Selected Gaging Station Records for Walnut Creek

Water Year 1991

	Walnut Creek at Indiana Street				A-4 Discharge				B-5 Transfer to Pond A-4
	GS03				**GS11**				**GS03 (flowmeter)**
	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft
Oct	NA	NR	NR	NR	14.36	0.24	NR	0.34	34.59
Nov	NA	NR	NR	NR	13.89	0.23	NR	0.50	2.45
Dec	NA	NR	NR	NR	0.00	0.00	NR	0.00	0.00
Jan	6.36	0.10	0.00	0.51	2.26	0.04	NR	0.23	16.96
Feb	NA	NR	NR	NR	24.74	0.42	NR	0.44	20.68
Mar	27.36	0.44	0.32	0.61	28.33	0.48	NR	0.43	31.07
Apr	22.33	0.36	0.36	0.36	15.39	0.26	NR	0.42	25.97
May	NA	NR	NR	NR	32.87	0.55	NR	1.26	68.37
Jun	115.20	1.87	1.54	2.40	99.55	1.67	NR	2.54	53.80
Jul	11.63	0.19	0.00	1.45	8.41	0.14	NR	0.87	21.95
Aug	23.01	0.37	0.00	2.14	15.38	0.26	NR	1.21	39.40
Sep	38.75	0.65	0.00	1.82	26.90	0.45	NR	1.05	21.04

Water Year 1992

	Walnut Creek at Indiana Street				A-4 Discharge				B-5 Transfer to Pond A-4
	GS03				**GS11**				**GS03 (flowmeter)**
	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft
Oct	18.24	0.30	0.00	1.79	17.08	0.29	NR	1.19	0.00
Nov	1.75	0.03	0.00	0.36	0.00	0.00	NR	0.00	35.14
Dec	23.11	0.38	0.00	1.16	58.17	0.98	NR	1.31	42.47
Jan	12.52	0.20	0.01	0.83	23.29	0.39	NR	1.11	20.35
Feb	8.57	0.14	0.01	0.66	11.41	0.19	NR	0.84	24.06
Mar	235.45	3.83	0.05	11.02	95.19	1.60	NR	3.08	51.71
Apr	61.85	1.01	0.09	4.15	37.55	0.63	NR	2.38	37.73
May	33.86	0.55	0.07	2.03	33.51	0.55	0.00	1.41	5.02
Jun	29.65	0.48	0.09	2.43	10.86	0.18	0.00	1.39	49.39
Jul	60.39	0.98	0.07	1.95	34.44	0.56	0.00	1.46	26.62
Aug	4.44	0.07	0.06	0.09	0.11	0.00	0.00	0.00	18.70
Sep	66.93	1.12	0.06	2.96	54.40	0.91	0.00	2.43	43.69

Water Year 1993

	Walnut Creek at Indiana Street				A-4 Discharge				B-5 Transfer to Pond A-4
	GS03				**GS11**				**GS03 (flowmeter)**
	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft
Oct	11.61	0.19	0.00	0.83	19.64	0.32	0.00	1.30	7.53
Nov	0.01	0.00	0.00	0.00	0.10	0.00	0.00	0.01	30.06
Dec	37.78	0.61	0.00	2.12	54.78	0.89	0.00	2.90	40.01
Jan	0.33	0.01	0.00	0.01	0.01	0.00	0.00	0.00	27.01
Feb	24.66	0.44	0.01	1.09	27.79	0.50	0.00	1.26	7.98
Mar	15.05	0.24	0.00	2.06	16.89	0.27	0.00	2.11	24.77
Apr	105.14	1.77	0.03	3.88	118.65	1.99	0.00	3.36	77.16
May	3.95	0.06	0.00	0.58	0.00	0.00	0.00	0.00	21.18
Jun	18.70	0.31	0.00	1.93	23.32	0.39	0.00	1.90	28.85
Jul	20.65	0.34	0.00	1.42	29.49	0.48	0.00	1.95	11.36
Aug	30.70	0.50	0.00	1.54	40.37	0.66	0.00	2.05	34.99
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.97

Water Year 1994

	Walnut Creek at Indiana Street				A-4 Discharge				B-5 Transfer to Pond A-4
	GS03				**GS11**				**GS03 (flowmeter)**
	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac ft	Average Monthly Flow (cfs)	Min Monthly Flow (cfs)	Max Monthly Flow (cfs)	Yield Volume Ac-ft
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.72
Nov	30.16	0.51	0.00	1.67	55.24	0.93	0.00	2.16	44.20
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.27
Jan	0.00	0.00	0.00	0.00	59.29	0.96	0.00	1.99	35.91
Feb	NA	NR	NR	NR	0.00	0.00	0.00	0.00	20.26
Mar	55.78	0.91	0.00	2.56	29.07	0.47	0.00	1.72	31.53 (note 2)
Apr	51.26	0.86	0.01	2.31	39.42	0.66	0.00	1.68	26.39
May	27.07	0.44	0.01	1.80	24.40	0.40	0.00	2.01	37.14
Jun	23.43	0.39	0.00	1.43	34.61	0.58	0.00	1.98	14.12
Jul	21.67	0.35	0.00	1.45	27.49	0.45	0.00	1.71	12.89
Aug	1.46	0.02	0.01	0.05	0.00	0.00	0.00	0.00	26.58
Sep	28.96	0.49	0.02	1.33	28.54	0.48	0.00	1.73	35.82

NR = no record
NA = not applicable
Note 1: GS11 flow record begins in May 1992. Adjusted daily flow records used for 10/90 to 4/92.
Note 2: 4.22 Ac-Ft (1.37 Mgal) direct discharge on 3/23 - 3/24.

APPENDIX B
WATER QUALITY CHARACTERISTICS OF WALNUT CREEK AND WOMAN CREEK

The water quality parameters of importance to this study because of their influence on aquatic organism viability are dissolved oxygen (DO), temperature, total suspended solids (TSS), pH, metals, orthophosphate, nitrogen, and particularly un-ionized ammonia. Historic and recently collected data of interest to this project, because of the location of the samples, analytes of concern, and/or collection of contemporaneous benthic data, were identified from the data sets summarized below.

B.1 1991 *BASELINE BIOLOGICAL CHARACTERIZATION OF THE TERRESTRIAL AND AQUATIC HABITATS AT THE ROCKY FLATS PLANT*

Water quality and biological samples were collected in the spring and fall of 1991 to support the *Baseline Biological Characterization of the Terrestrial and Aquatic Habitats at the Rocky Flats Plant* (EG&G 1992). The field parameters pH, DO, temperature, conductivity, and turbidity were measured concurrently with collection of the aquatic samples. General water quality indicators such as alkalinity, free and total acidity, total hardness, TSS, sulfate, and the nutrients ammonia, nitrate and nitrite, and ortho-phosphate were measured using a HACH kit. Available water quality results collected in the spring and fall of 1991 are presented in Table B-1. No data was available from the Walnut Creek stations for the spring sampling; therefore, these results are not presented.

In the spring, temperatures were highest at Pond C-1 and relatively constant elsewhere. In Woman Creek, fall temperatures increased in the downstream direction from between 6.0 to 7.5 degrees C above Pond C-1 to 10.0 to 11.0 degrees C at and below Pond C-1. This temperature rise may be may be attributed to the fact that the downstream samples were collected in the mid-afternoon when air temperatures are expected to be higher while the upstream samples were collected before 10 a.m. Corresponding with the increase in temperature at the downstream stations in the fall, DO decreased with downstream position. The pH remained relatively constant during both the spring and fall sampling rounds, ranging between 7.2 and 8.4. In the fall, conductivity and TSS increased with downstream direction indicating that the stream gains both dissolved constituents and particulates with downstream distance.

Available water quality data for Walnut Creek was limited to the five B-series ponds, one downstream station on the main stem of the creek, and a station at the pond at Walnut and Indiana. As seen in Table B-4, most parameters remained relatively constant except for at the pond at Walnut and Indiana. Temperature at this station was considerably lower than the other ponds and showed a corresponding increase in DO, but did not exhibit a significant difference in un-ionized ammonia. Values of pH and other parameters were within the same range as Woman Creek, with the exception of ortho-phosphate, which was consistently higher in Woman Creek.

In the 1991 study, calculated un-ionized ammonia concentrations at all Woman Creek stations and at the two Walnut Creek stations below Pond A-4 were well below the Segment 4 standard of 0.1 mg/L and showed no discernable trend with downstream position. Un-ionized ammonia concentrations were calculated from measured values for total ammonia, pH, and temperature using standard thermodynamic equations.

Water quality data for the stream reaches are not available for the time period between 1991 and July 1994. However, significant water quality changes are not suspected during this period, based on pond water quality data for the same period and stream water quality data for July and September 1994.

B.2 1994 WATER QUALITY ASSESSMENT

Water quality data collected concurrent with the 1994 macroinvertebrate sampling are presented in Tables B-2 through B-4. Total and un-ionized ammonia concentrations are plotted in Figures B-1 and B-2 which show concentrations as a function of downstream position during the July and September release period and during the September non-release period.

The pH of pond samples collected in September 1994 ranged from 6.98 in Pond B-3 to 9.65 in Pond A-4, indicating that pH tends to increase as water moves through the pond system and is detained in Pond A-4. The pH of the Pond A-4 effluent was quite high during both the July and September release, with values above 10 in both instances. The shift in pH through Ponds B-3, B-5, and A-4 strongly influences un-ionized ammonia concentrations. At higher pH values a larger percentage of total ammonia will be in the un-ionized form. Therefore, even though total ammonia concentrations are highest in Pond B-3 (Figure B-1), the increased pH and temperature in downstream ponds causes un-ionized ammonia to peak in Pond B-5 (Figure B-2).

Figures B-1 and B-2 also indicate that both total ammonia and un-ionized ammonia concentrations drop considerably by Indiana Street. At this location, un-ionized ammonia is well below the underlying Segment 4 standard of 0.1 mg/L. (It is important to note that non-detected values of total ammonia are presented as one-half the detection limit in Tables B-2 through B-4 in order to calculate an un-ionized concentration.)

The results of sampling total and un-ionized ammonia in effluent from Pond A-4 and at two downstream locations is presented in Table B-5. These results indicate that total ammonia levels in A-4 effluent dropped steadily throughout the summer. During July and September, all samples were below the detection limit. These values are questionable, however, because they are below values measured in July and September during macroinvertebrate sampling (Tables B-2 through B-4) and are below historic average values. However, if the July and September samples are disregarded, earlier results from samples collected in March, April, and June show that un-ionized ammonia is well below the standard of 0.1 mg/L. In addition, except for one sample collected on April 8, concentrations decrease between Pond A-4 effluent and the end of the Broomfield Diversion Ditch.

B.3 POND WATER QUALITY DATA

B.3.1 Rocky Flats Environmental Database System Data Summary

Water quality has been routinely monitored in the detention ponds as part of ongoing National Pollutant Discharge Elimination System (NPDES) compliance (EG&G 1993). This data is useful in determining the general quality of water that has been released to the Walnut Creek drainage and which has influenced the aquatic community in the ponds and in the reaches below the ponds. Validated analytical data collected from Ponds A-3, A-4, and B-5 in January 1990 to March 1994 were retrieved from the Rocky Flats Environmental Database System (RFEDS) to support data analysis in the *Final Draft Pond Water Management Interim Measures/Interim Remedial Action Decision Document* (EG&G 1994). For purposes of comparison, the 85th percentile value was calculated for each sample population and compared to Segment 4 or 5 stream standards, where appropriate. The 85th percentile value was obtained by ranking all numeric data available for a given parameter and then converting the ranking to a scale of 1 to 100, and selecting the 85th value. This 85th percentile calculation is identical to the method used in 1992 to calculate temporary modifications to Segment 5 standards based on ambient background data.

For this study, summary statistics for constituents having potential adverse effects on aquatic life were reviewed. These constituents included total and dissolved metals, organic chemicals, and standard water quality parameters, including total and un-ionized ammonia.

Summary statistics for the organics that had at least one detected sample (at any location) revealed that the pesticide 4,4-DDT was detected in each of the terminal ponds. Methylene chloride and bis(2-ethylhexyl)phthalate were detected at several of the ponds, but are often laboratory contaminants or sampling artifacts. Other organics detected one or two times at one or more ponds at levels that exceeded stream standards included trichloroethylene, naphthalene, and chloroform (EG&G 1994).

For total metals, some minor trends in the variation of concentration with time were identified for total barium, lithium, magnesium, and sodium. Barium concentrations decreased over time at Ponds A-4 and B-5. Variations of lithium concentration over time at Ponds A-4 and B-5 is characterized by an abrupt increase around November 1991 and then a gradual decline in concentration. Standards for lead and iron were infrequently exceeded in Ponds A-4 and B-5 (EG&G 1994).

For dissolved metals, the 85th percentile for manganese exceeded stream standards at Ponds A-3 and B-5. The same trends for the total barium, lithium, magnesium, and sodium data are also evident in the dissolved data for these analytes. Infrequent exceedances occurred for manganese and mercury in Pond A-3, and for manganese, mercury, silver, and thallium in Ponds A-4 and B-5 (EG&G 1994).

Water quality parameters which were occasionally elevated with respect to standards included chloride, cyanide, sulfide, sulfate, and nitrite. The total ammonia data for Pond A-4 show a cyclical pattern with larger concentrations in about February and lower concentrations in about July. The Pond A-4 results for bicarbonate as calcium carbonate and chloride also show similar patterns (EG&G 1994).

Un-ionized ammonia concentrations in the ponds are of particular interest to this study. Available un-ionized ammonia data for the Walnut Creek drainage ponds affected by WWTP discharges are plotted on Figures B-3 through B-5. Limited data is available for Pond B-3 and, therefore, trends in concentrations are difficult to assess. Based on 1½ years of data from Pond B-5, concentrations typically peak in late November and during March through June. Pond A-4 concentrations measured over a slightly longer time period (Figure B-5) also showed consistently higher values in March through June.

B.3.2 Vertical Variation in Pond Water Quality

During the summer of 1992, EG&G's Surface Water staff obtained vertical profiles for selected water quality parameters in Ponds A-4, B-5, and C-2. The purpose of the study was to establish the degree of vertical variation in water quality in the ponds using the selected parameters of temperature, pH, dissolved oxygen, and redox potential (EG&G 1992b).

The study reported that temperature is the primary indicator of stratification in the ponds, and that all three ponds develop some temperature stratification on a routine basis, which is persistent during the summer months. Stratification is most pronounced in Pond A-4, least pronounced in Pond C-2, and intermediate in Pond B-5. Additions of water to each pond did not reduce the stratification but instead increased the thickness of the epilimnion. Deeper water bodies, such as Pond A-4, stratify more stably than shallower bodies such as Pond C-2, owing to the greater degree of isolation of deeper waters from the actions of wind, which would tend to mix the water column. Surface temperatures in Pond A-4 were typically 5 degrees C higher than temperatures at depth (EG&G 1992b). Even Pond C-2, which is only 2 to 2.5 meters deep, showed some vertical stratification during early summer months (DOE 1994). Discontinuities in density or temperature observed in the uppermost 1 to 1.5 meters of all of the ponds were shown to disappear within a relatively short time (i.e., overnight) (EG&G 1992b).

Dissolved oxygen profiles of Ponds A-4, B-5, and C-2 indicate a zone of strong oxygen depletion adjacent to the bottom sediments that is seasonally persistent. Because the subsurface layers of these ponds are typically located below the zone of photosynthesis and the ponds stratify, these layers have no internal oxygen source. Coupled with microbiological activity and sources of biochemical oxygen demand, oxygen decline is a standard and persistent phenomenon in the ponds. The zone of oxygen depletion in Pond A-4 was shown to be as much as 10 feet thick and displayed concentrations below 1.0 mg/L, indicating that this layer had been effectively isolated from oxygen sources for a week or more. However, even the shallowest pond, Pond C-2, exhibited strong oxygen depletion near the bottom sediments during times of no flow (EG&G 1992b).

B.4 CONCLUSIONS REGARDING STREAM AND POND WATER QUALITY

A review of historic water quality data has revealed that the water quality within the Walnut Creek drainage generally complies with imposed water quality standards and compares favorably to Woman Creek. The limited data available from stream channel locations indicates that water quality parameters such as DO, temperature, and pH are similar in magnitude to that in Woman Creek and are within ranges which can support aquatic life. In sampling conducted in 1991 and 1994, none of the water quality parameters were detected in downstream locations at concentrations above background for the region.

Historic pond data is more abundant and reveals that the most significant limitation to aquatic life is likely to be oxygen depletion at depth during periods of temperature stratification. Other important water quality parameters, such as un-ionized ammonia and some dissolved metals, have fluctuated in concentration and have infrequently exceeded standards set to protect aquatic life. The only metals which have exceeded standards were manganese, mercury, silver, and thallium.

A detailed assessment of water quality parameters other than ammonia was not performed. Such an evaluation may be useful in refining conclusions from the bioassessment and determining if variations in macroinvertebrate metric values are being caused by chemical constituents. However, as stated in Chapter 3, correlations between metrics and ammonia levels were not seen. Although other water quality issues may be relevant in determining potential causes of impairment, un-ionized ammonia concentrations are not considered a significant impairment to Walnut Creek.

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EG&G. 1992a. *Baseline Biological Characterization of the Terrestrial and Aquatic Habitats at the Rocky Flats Plant.* Final Report.

______. 1992b. Summary and Interpretation of the Profiles for Selected Water Quality Variables in Ponds A4, B5, and C2. (Unpublished).

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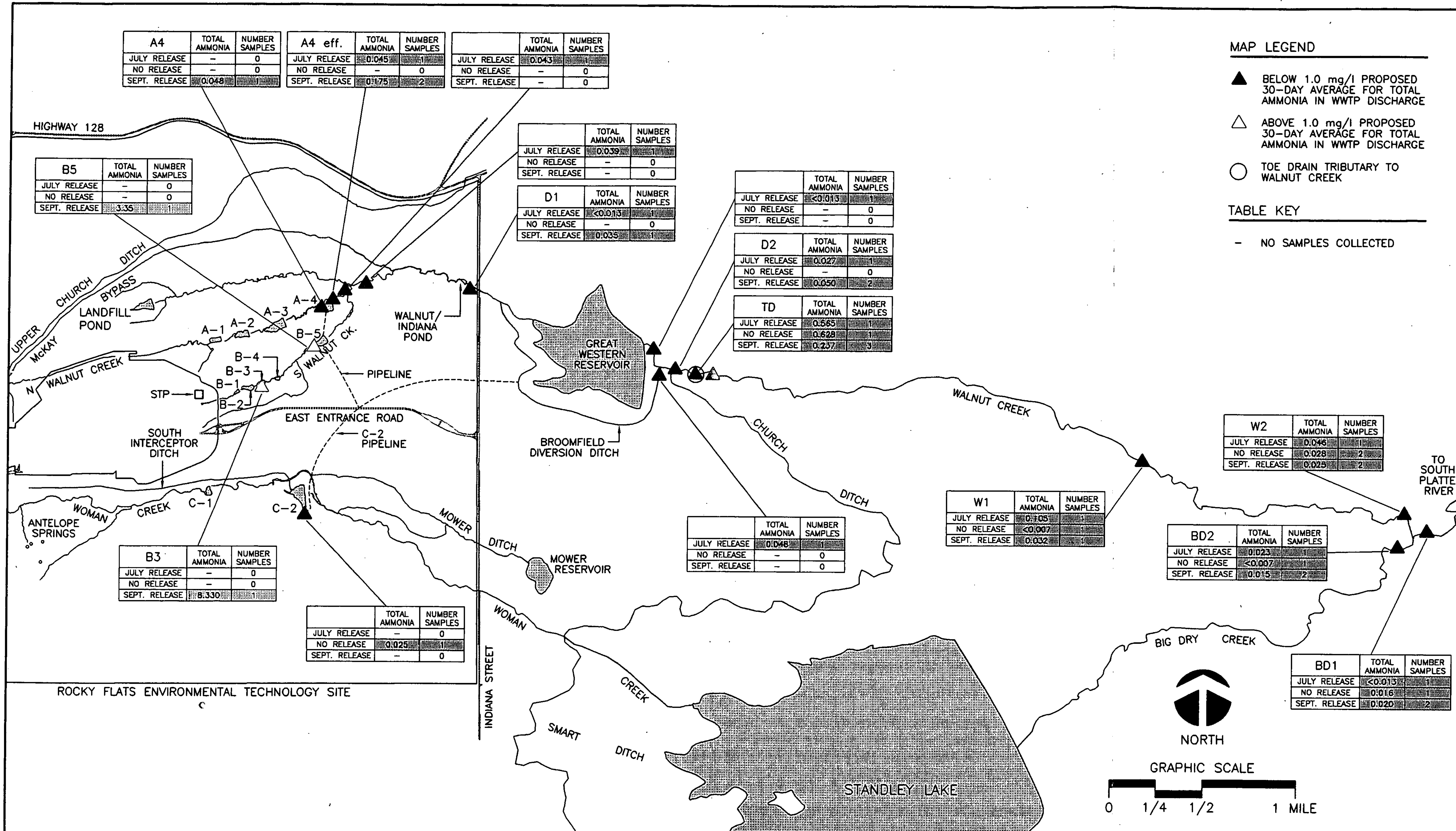

A4	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	–	0
NO RELEASE	–	0
SEPT. RELEASE	0.048	1

A4 eff.	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.045	1
NO RELEASE	–	0
SEPT. RELEASE	0.175	2

	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.043	1
NO RELEASE	–	0
SEPT. RELEASE	–	0

B5	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	–	0
NO RELEASE	–	0
SEPT. RELEASE	3.35	1

	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.039	1
NO RELEASE	–	0
SEPT. RELEASE	–	0

D1	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	<0.013	1
NO RELEASE	–	0
SEPT. RELEASE	0.035	1

	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	<0.013	1
NO RELEASE	–	0
SEPT. RELEASE	–	0

D2	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.027	1
NO RELEASE	–	0
SEPT. RELEASE	0.050	2

TD	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.565	1
NO RELEASE	0.628	1
SEPT. RELEASE	0.237	3

W2	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.046	1
NO RELEASE	0.028	2
SEPT. RELEASE	0.025	2

	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.048	1
NO RELEASE	–	0
SEPT. RELEASE	–	0

W1	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.105	1
NO RELEASE	<0.007	1
SEPT. RELEASE	0.032	1

BD2	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	0.023	1
NO RELEASE	<0.007	1
SEPT. RELEASE	0.015	2

B3	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	–	0
NO RELEASE	–	0
SEPT. RELEASE	8.330	1

	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	–	0
NO RELEASE	0.025	1
SEPT. RELEASE	–	0

BD1	TOTAL AMMONIA	NUMBER SAMPLES
JULY RELEASE	<0.013	1
NO RELEASE	0.016	1
SEPT. RELEASE	0.020	2

PROJ. NO.	901-004.330	DWG. NO.	1
DESIGN BY	KA	CHECKED	EWM
DRAWN BY	KAL	APPROVED	–
DATE	FEB. 21, 1995	SCALE	1"=1/2 MILE

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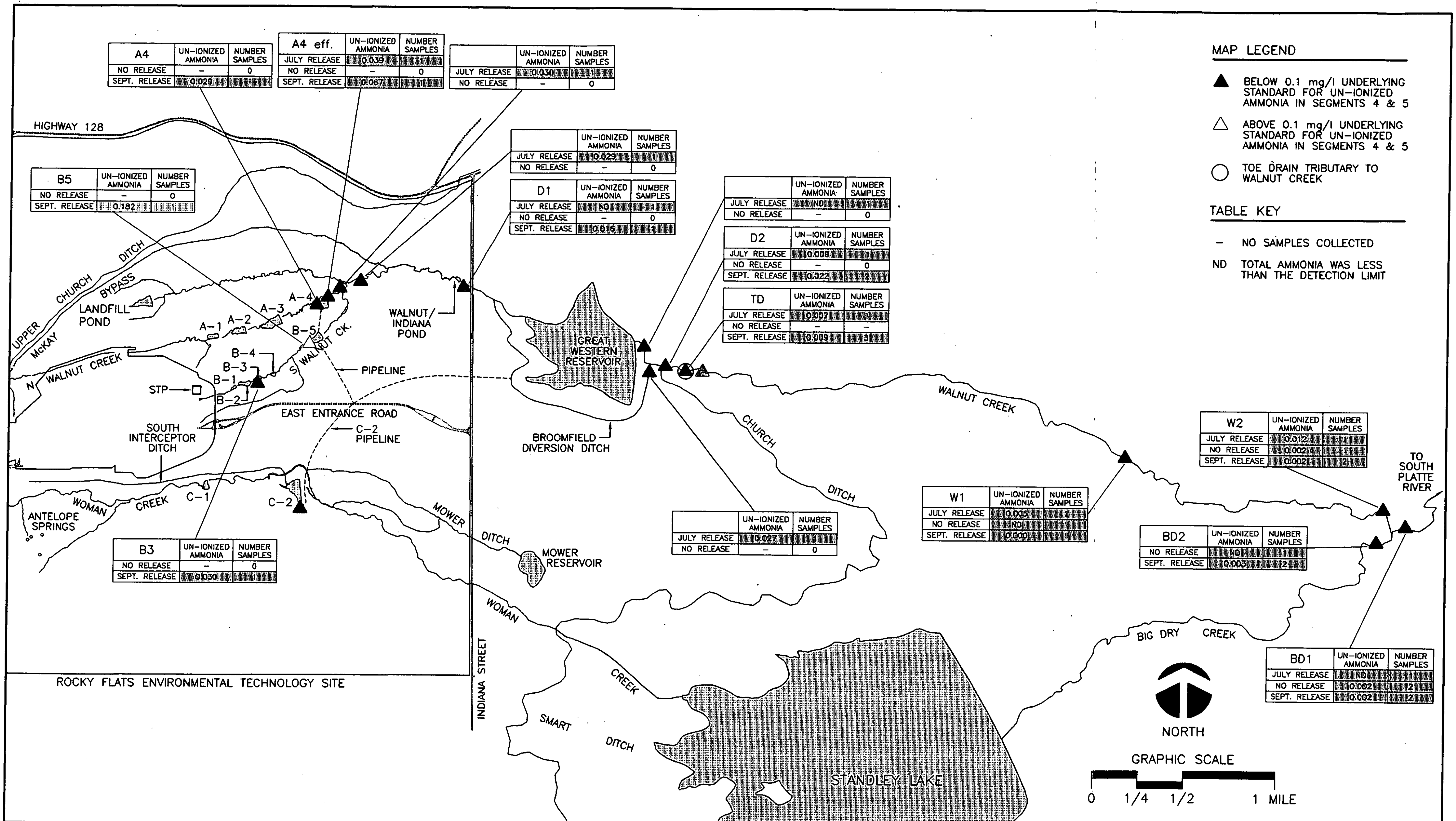
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

FIGURE B-1
TOTAL AMMONIA CONCENTRATIONS



PROJ. NO.	901-004.330	DWG. NO.	1
DESIGN BY	KA	CHECKED	EWM
DRAWN BY	KAL	APPROVED	–
DATE	FEB. 21, 1995	SCALE	1"=1/2 MILE

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ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

FIGURE B-2
UN-IONIZED AMMONIA CONCENTRATIONS

Figure B-3
Pond B-3 Un-ionized Ammonia

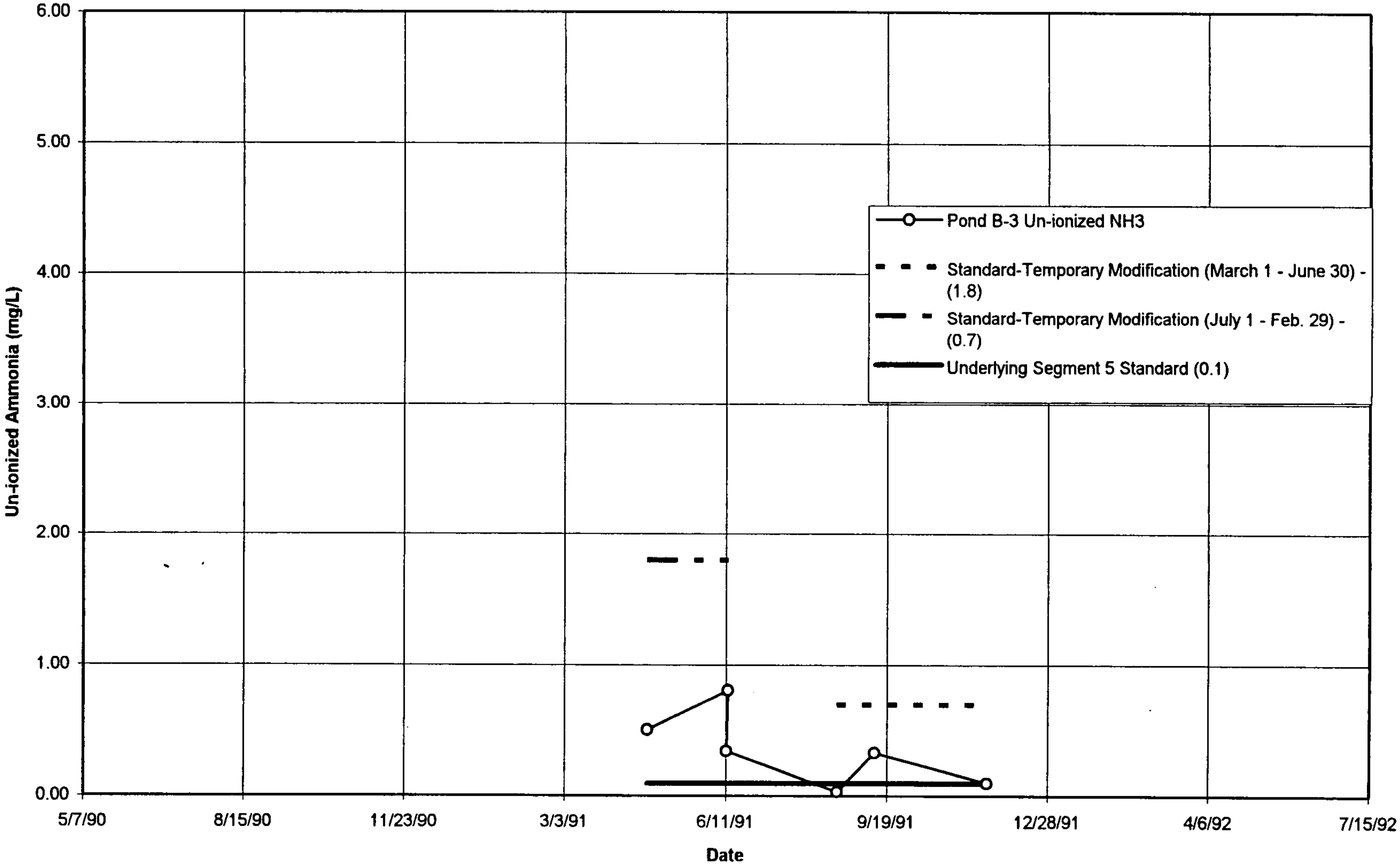

Figure B-4
Pond B-5 Un-ionized Ammonia

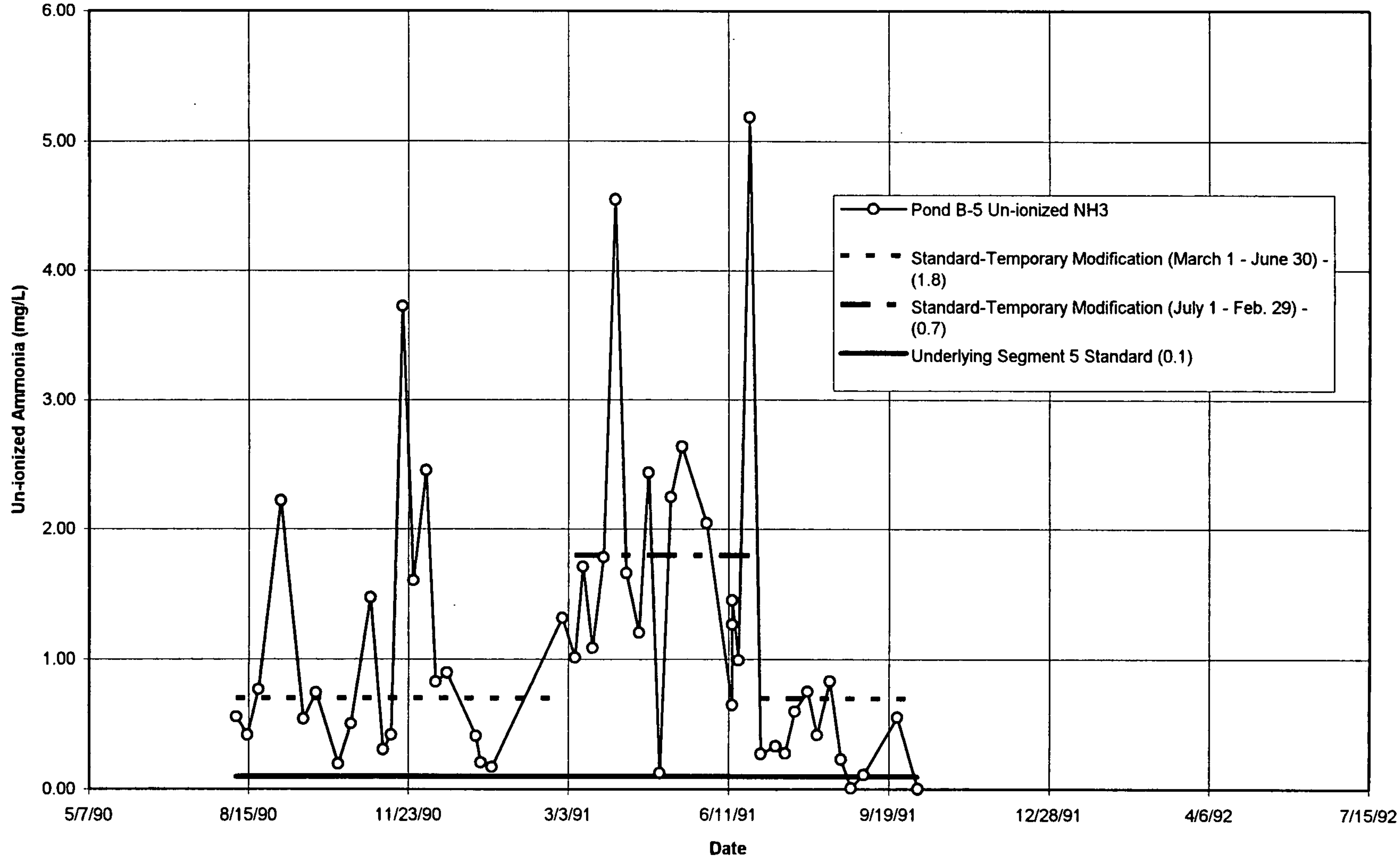

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Figure B-5
Pond A-4 Un-ionized Ammonia

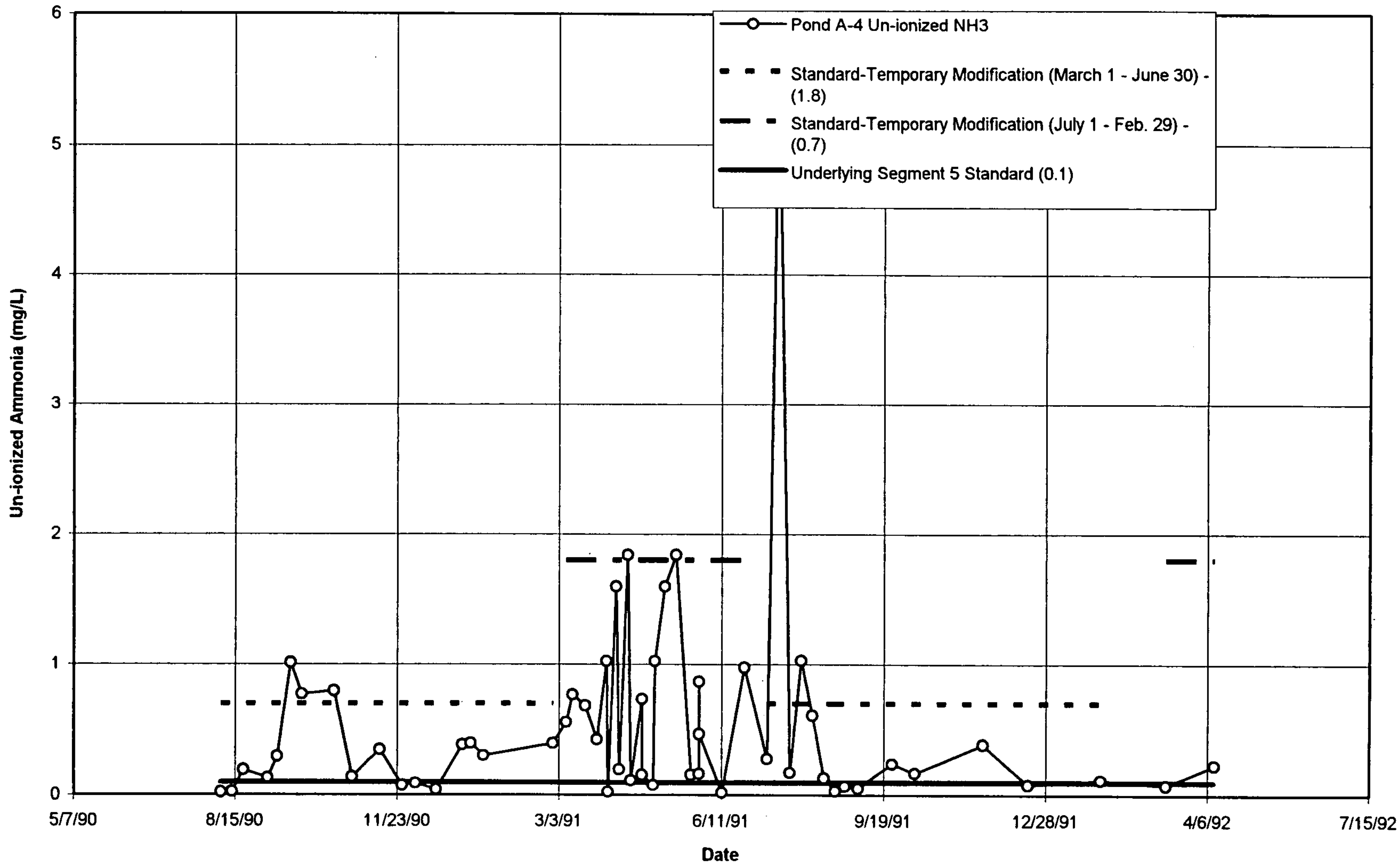

TABLE B-1
WALNUT AND WOMAN CREEK WATER QUALITY RESULTS
SPRING/FALL 1991

	Temp. (C)	D.O. (mg/L)	pH (s.u.)	Conductivity (μmhos/cm)	TSS (mg/L)	Total Ammonia as N (mg/L)	Un-ionized Ammonia (mg/L)	Total Alkalinity (mg/L $CaCO_3$)	Total Hardness (mg/L $CaCO_3$)	Nitrate (mg/L)	Ortho-Phosphate (mg/L)	Total Iron (mg/L)	Chloride (mg/L)
Woman Creek													
SW39	15.0/7.5	8.8/10.5	7.8/7.8	280/182	12/10	0.23/0.25	.0037/.0029	89/74	99/79	0.8/1.6	0.48/4.7	0.28/0.	22/20
SW33	15.0/6.5	9.2/9.7	8.0/8.0	320/380	10/9	0.21/0.43	.0056/.0080	112/146	141/158	0.5/1.7	0.36/4.8	0.22	24/20
WOR13	- /6.0	5.2/10.5	- /8.1	- /420	- /10	- /0.27	- /.0054	- /156	- /156	- /2.3	- /5.0	0.18	--/--
SWC1	19.0/10.0	18.2/0.6	8.2/8.2	420/430	8/36	0.38/0.40	.0210/.0143	130/159	141/180	0.9/0.8	0.88/4.8	0.46	25/32
WORI1	17.0/10.0	7.8/8.8	7.9/8.1	420/480	8/24	0.36/0.26	.0089/.0066	139/183	150/190	0.6/0.8	0.64/4.9	0.26	30/20
SW26	18.0/10.0	8.5/9.6	8.1/8.4	450/520	14/34	0.34/0.35	.0141/.0182	160/186	170/200	0.6/0.8	0.98/4.7	0.34	35/42
WOP01	17.0/11.0	6.6/5.9	7.2/7.7	600/1090	5/32	0.28/1.01	.0014/.0115	230/262	213/265	0.5/0.6	1.18/5.2	0.17	80/71
WOP02	16.0/11.0	- /6.2	7.4/8.0	680/870	8/22	0.37/0.49	.0027/.0105	223/277	214/204	0.6/1.1	0.87/--	0.23	38/54
Walnut Creek													
SWB3	- /12.0	- /8.0	- /7.50	- /660	- /10	- /1.00	- /.00831	- /138	- /114	- /3.20	- /0.34	- /0.12	- /64
SWB4	- /12.0	- /8.0	- /7.80	- /690	- /12	- /1.00	- /.01646	- /135	- /135	- /4.20	- /0.85	- /0.15	- /71
SWB5	- /10.0	- /9.5	- /7.60	- /610	- /15	- /1.00	- /.00894	- /121	- /149	- /5.20	- /0.60	- /0.15	- /48
WARI1	- /11.0	- /5.6	- /7.50	- /650	- /10	- /0.16	- /.00123	- /104	- /240	- /0.60	- /0.14	- /0.05	- /40
SW03	- /7.0	- /10.3	- /8.20	- /580	- /16	- /0.46	- /.01270	- /142	- /192	- /0.70	- /0.12	- /0.08	- /38

Source: Data collected as part of the *Baseline Characterization of the Terrestrial and Aquatic Habitats at the Rocky Flats Plant.*

Note: Un-ionized Ammonia was calculated from total ammonia as N using thermodynamic data from, *Aqueous/Environmental Geochemistry, Draft, August 1992,* by Donald Langmuir.

Table B-2
Water Quality Analysis for Walnut Creek
July 1994 (Release)

Location	pH	Temp. C	Un-Ionized NH3 mg/L	Total Ammonia mg/L	HARD mg/L	HCO3 mg/L	CO3 mg/L	TDS mg/L	TSS mg/L	COND mg/L	Cl mg/L	PO4 mg/L	NO3 mg/L	SO4 mg/L	Na mg/L	K mg/L	Ca mg/L
BD1	8.57	20	0.0008	0.0065	93.4	67.8	<3	166	22	257.6	10.98	<0.09	0.84	53.06	18.65	2.42	27.51
BD2	8.52			0.023	90.3	67.3	<3	156	48	257.6	10.79	<0.08	0.83	50.63	18.13	2.34	26.22
D1	9.41	24	0.0037	0.0065	143.0	80.2	22.5	340.0	16.0	553.1	72.84	0.15	<0.02	54.49	60.03	8.06	41.33
D2	9.08	20	0.0087	0.027	111.7	85.0	3.7	266.0	<10	412.4	49.37	<0.1	<0.03	43.74	41.21	5.24	32.66
D3	9.48	21	0.0270	0.048	127.8	79.4	16.5	326.0	<10	541.8	73.62	<0.09	<0.03	54.68	59.63	7.52	36.29
GWR Spill	8.03	21	0.0003	0.0065	55.4	44.8	<3	104.0	<10	147.8	5.19	<0.09	<0.03	23.64	8.64	1.45	16.67
TD	7.75	12	0.0068	0.565	223.9	265.6	<3	270.0	<10	482.7	8.40	<0.1	1.04	18.17	32.23	1.24	57.78
W1	8.08	20	0.0048	0.105	401.4	384.3	<3	1046.0	<10	1597.0	74.63	<1.27	2.43	420.84	205.57	3.78	85.70
W2	8.77	25	0.0115	0.046	310.1	255.6	8.9	796	<10	1228	55.58	<0.09	<0.03	331.83	167.87	4.04	69.18
A4EF	10.16	22	0.0391	0.045	139.1	24.6	49.1	332	<10	555.9	72.33	<0.08	<0.02	52.39	59.25	8.19	41.16
D3A	9.75	24	0.0292	0.039	128.1	58.4	32.3	328	26	536.2	71.98	0.13	<0.02	53.22	59.1	8.1	37.22
D4A	9.71	22	0.0302	0.043	135.9	64.5	30.2	340	<10	539	72.19	0.11	<0.02	52.8	58.55	8.08	39.74

Location	Mg mg/L	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Cd mg/L	Co mg/L	Cr mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Ni mg/L	Pb mg/L	Zn mg/L
BD1	5.99	<0.0018	0.0681	<0.009	0.017	0.034	<0.0002	<0.0005	<0.0004	<0.0027	0.005	0.081	0.0332	0.0019	<0.0057	0.0179
BD2	6.03	<0.0018	0.0753	0.037	0.017	0.034	0.0023	0.0021	0.0028	<0.0027	0.003	0.043	0.024	0.0036	<0.0057	0.0133
D1	9.66	<0.0018	0.0146	<0.009	0.058	0.046	<0.0002	<0.0005	0.0012	<0.0027	<0.003	0.030	0.0113	0.0027	<0.0057	0.0110
D2	7.31	<0.0018	0.0525	<0.009	0.042	0.046	0.0004	<0.0005	0.0009	<0.0027	0.004	0.047	0.0123	0.0028	<0.0057	0.0116
D3	9.03	<0.0018	0.0255	0.0310	0.056	0.044	<0.0002	<0.0005	0.0014	<0.0027	0.003	0.035	0.0052	0.0040	<0.0057	0.0113
GWR Spill	3.35	<0.0018	0.0199	<0.009	0.008	0.036	<0.0002	<0.0005	<0.0004	<0.0027	0.004	0.028	0.0023	0.0007	<0.0057	0.0093
TD	19.34	<0.0018	<0.0053	<0.009	0.065	0.168	<0.0002	<0.0005	<0.0004	<0.0027	<0.003	0.513	0.5900	0.0026	<0.0057	0.0174
W1	45.51	<0.0018	0.0210	<0.009	0.214	0.057	<0.0002	<0.0005	<0.0004	<0.0027	0.003	0.090	0.1018	0.0053	<0.0057	0.0226
W2	33.35	<0.0018	0.0102	<0.009	0.173	0.071	<0.0002	<0.0005	0.0004	<0.0027	0.004	0.028	0.0424	0.0032	<0.0057	0.0154
A4EF	8.82	<0.0018	0.01	<0.009	0.057	0.042	<0.0002	<0.0005	0.0009	<0.0027	<0.003	0.026	0.004	0.0026	<0.0057	0.0105
D3A	8.55	<0.0018	0.0086	0.029	0.055	0.036	0.0004	<0.0005	0.0015	<0.0027	<0.003	0.016	0.0091	0.0031	<0.0057	0.0112
D4A	8.91	<0.0018	0.0121	0.017	0.057	0.039	<0.0002	<0.0005	0.0016	<0.0027	0.003	0.027	0.0094	0.0028	<0.0057	0.0113

Note:
Non-detected values of total ammonia are shown as 1/2 the detection limit to allow calculation of un-ionized ammonia.

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Table B-3
Water Quality Analysis for Walnut Creek
September 1994 (No Release)

Location	pH	Temp. C	NH3 mg/L	NH3+NH4 mg/L	HARD mg/L	HCO3 mg/L	CO3 mg/L	TDS mg/L	TSS mg/L	COND mg/L	Cl mg/L	PO4 mg/L	NO3 mg/L	SO4 mg/L	Na mg/L	K mg/L	Ca mg/L
C2	8.26			0.025	197.4	278.2	<3	428	<10	709.4	65.01	<0.6	<0.19	43.88	74.88	6.66	44.4
BD1	8.53	18.5	0.0031	0.029	75.1	73.2	<3	158	<10	236.3	9.19	<0.1	0.62	42.96	16.35	2.27	21.65
BD1	8.43	18.5	0.0003	0.0035													
BD2	8.38	19.7	0.0003	0.0035	75.6	65	<3	152	<10	236.3	9.1	<0.1	0.52	42.4	16.03	2.16	21.77
BD2	8.38	19.7	0.0003	0.0035													
TD	6.86			0.63	184.4	294	<3	284	<10	480.5	9.01	<0.09	0.86	16.59	32.51	1.07	47.55
TD	6.86			0.625													
W1	7.75	15	0.0001	0.0035	370	297.7	<3	1002	<10	1461	65.25	<0.14	0.92	427.4	189.63	4.31	82.04
W1	7.75	15	0.0001	0.0035													
W2	8.25	18.8	0.0020	0.033	359.8	336.7	<3	966	<10	1416	61.3	<0.14	<0.03	382.22	187.12	4.82	81.85
W2	8.25	18.8	0.0013	0.022													

Location	Mg mg/L	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Cd mg/L	Co mg/L	Cr mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Ni mg/L	Pb mg/L	Zn mg/L
C2	21.01	<0.0018	<0.0053	0.032	0.101	0.084	<0.0002	<0.0005	<0.0004	<0.0027	0.004	0.07	0.0009	0.0019	<0.0057	0.0137
BD1	5.12	<0.0018	<0.0053	0.013	0.021	0.028	0.0003	<0.0005	<0.0004	<0.0027	<0.003	0.007	0.2425	0.0015	<0.0057	0.006
BD1																
BD2	5.15	<0.0018	0.0226	0.01	0.017	0.028	<0.0002	<0.0005	<0.0004	<0.0027	<0.003	0.02	0.2337	0.0008	<0.0057	0.0057
BD2																
TD	15.94	<0.0018	<0.0053	<0.009	0.07	0.207	<0.0002	<0.0005	<0.0004	<0.0027	<0.003	0.519	0.4565	0.0015	<0.0057	0.0113
TD																
W1	40.1	<0.0018	0.0235	0.027	0.188	0.051	<0.0002	<0.0005	<0.0004	<0.0027	<0.003	0.057	0.0294	0.0036	<0.0057	0.0134
W1																
W2	37.74	<0.0018	0.0119	<0.009	0.203	0.078	<0.0002	<0.0005	0.0004	<0.0027	<0.003	0.018	0.0315	0.0038	<0.0057	0.0108
W2																

Note:
Non-detected values of total ammonia are shown as 1/2 the detection limit to allow calculation of un-ionized ammonia.

Table B-4
Water Quality Analysis for Walnut Creek
September 1994 (Release)

Location	pH	Temp. C	NH3 mg/L	NH3+NH4 mg/L	HARD mg/L	HCO3 mg/L	CO3 mg/L	TDS mg/L	TSS mg/L	COND mg/L	Cl mg/L	PO4 mg/L	NO3 mg/L	SO4 mg/L	Na mg/L	K mg/L	Ca mg/L
A4	9.65	18.5	0.0325	0.053	117.2	57.1	32.8	312	<10	495	66.16	<0.14	<0.03	41.14	53.4	9.31	31.94
A4	9.65	18.5	0.0264	0.043													
A4EF																	
A4EF	9.23	18.8	0.0667	0.175													
B3	6.98	19.4	0.0303	8.402	97.3	105.4	<3	210	<10	396.9	34.34	2.79	14.01	29.99	25.39	8.24	32.07
B3	6.98	19.4	0.0298	8.264													
B5	8.1	21.9		3.351													
D1	8.85	16.5	0.0061	0.034	127.4	98.1	14.3	328	<10	532.5	65.66	0.3	0.41	46.42	55.62	9.02	35.02
D1	8.85	16.5	0.0062	0.035													
D2	8.57	16.4	0.0043	0.042	123.8	130.9	<3	268	<10	449.5	42.49	<0.13	0.67	36.88	39.6	7.65	34.69
TD																	
TD	8.57	16.4	0.0031	0.031													
BD1	7.96	17.3	0.0006	0.022	83	73.3	<3	174	<10	265.7	11.23	<0.08	0.48	46.66	19.6	2.88	23.69
BD1	7.96			0.0025													
BD2	7.07	17.9	0.0001	0.022	78.7	68.1	<3	162	<10	246.2	9.31	<0.08	0.49	44.62	16.94	2.48	22.71
BD2	7.07	17.9	0.0000	0.0025													
W1	7.3	16.9	0.0002	0.032	144.6	145.2	<3	404	<10	619	62.95	<0.13	<0.02	77.09	68.06	7.95	37.38
W2	7.28	16.9	0.0002	0.032	169.9	168.4	<3	432	<10	713	63.88	<0.13	<0.02	108.08	79.97	7.47	42.74
W2	7.28	16.9	0.0000	0.0025													
A4EF	10.05			0.063	122.3	98.6	12.7	332	<10	504	66.24	0.33	<0.01	40.43	52.44	8.88	33.82
A4EF	10.05			0.053													
BD1	8.97	18.7	0.0078	0.031	148.7	145.2	<3	378	<10	585	49.16	<0.08	<0.01	91.43	62.06	6.02	38.99
BD1	8.97	18.7	0.0009	0.0035													
BD2	9.22	19.7	0.0117	0.03	104.7	74.5	10.3	226	<10	334	14.08	<0.08	0.05	64.37	28.1	2.73	29.94
BD2	9.22	19.7	0.0014	0.0035													
D1	9.83	19.1	0.0358	0.05	125.1	97.6	18.7	324	<10	518	67.22	0.32	0.03	41.83	53.95	8.97	34.83
D1	9.83	19.1	0.0157	0.022													
D2	9.78	19	0.0400	0.058	123.3	119.6	6.6	316	<10	516	65.84	0.12	0.04	41.45	52.38	8.36	33.97
TD	9.78	19	0.0241	0.035													
W2	8.54	18.4	0.0057	0.052	168	167.1	<3	442	<10	691	62.41	<0.08	<0.01	99.56	75.87	7.36	42.89
W2	8.54	18.4	0.0012	0.011													
TD	6.86	13.3	0.0011	0.642	189.9	281.1	<3	284	16	488	8.81	<0.08	0.88	15.39	33.5	1.72	48.64
TD	6.86	13.3	0.0011	0.646													

Location	Mg mg/L	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Cd mg/L	Co mg/L	Cr mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Ni mg/L	Pb mg/L	Zn mg/L
A4	9.1	<0.0018	<0.0053	0.024	0.059	0.03	<0.0002	<0.0005	0.0015	<0.0027	<0.003	0.008	0.0089	0.0028	<0.0057	0.0064
A4																
A4EF																
A4EF																
B3	4.17	<0.0018	0.0284	0.032	0.025	0.012	<0.0002	<0.0005	0.0004	<0.0027	<0.003	0.038	0.0148	0.001	<0.0057	0.0194
B3																
B5																
D1	9.7	<0.0018	0.0061	0.018	0.059	0.041	<0.0002	<0.0005	0.0015	<0.0027	<0.003	0.018	0.0064	0.0034	<0.0057	0.0071
D1																
D2	9.04	<0.0018	0.0114	<0.009	0.054	0.096	<0.0002	<0.0005	0.0007	<0.0027	<0.003	0.03	0.0094	0.0032	<0.0057	0.0074
TD																
TD																
BD1	5.79	<0.0018	0.0417	<0.009	0.021	0.035	<0.0002	<0.0005	<0.0004	<0.0027	<0.003	0.025	0.0665	0.0015	<0.0057	0.0068
BD1																
BD2	5.35	<0.0018	0.0526	<0.009	0.018	0.027	<0.0002	<0.0005	<0.0004	<0.0027	<0.003	0.026	0.0577	0.0009	<0.0057	0.0066
BD2																
W1	12.46	<0.0018	0.012	0.018	0.079	0.057	<0.0002	<0.0005	0.0012	<0.0027	0.003	0.049	0.0046	0.0029	<0.0057	0.013
W2	15.35	<0.0018	0.0262	<0.009	0.093	0.054	<0.0002	<0.0005	0.0005	<0.0027	0.003	0.041	0.0118	0.0033	<0.0057	0.0128
W2																
A4EF	9.18	<0.0018	0.0112	0.021	0.057	0.033	<0.0002	<0.0005	0.0016	<0.0027	<0.003	0.015	0.0137	0.0028	<0.0057	0.0069
A4EF																
BD1	12.46	<0.0018	0.0401	<0.009	0.066	0.048	<0.0002	<0.0005	0.0014	<0.0027	<0.003	0.043	0.0124	0.0028	<0.0057	0.011
BD1																
BD2	7.27	<0.0018	0.0467	<0.009	0.027	0.033	<0.0002	<0.0005	<0.0004	<0.0027	<0.003	0.033	0.0133	<0.0007	<0.0057	0.0065
BD2																
D1	9.26	<0.0018	0.0097	<0.009	0.059	0.042	<0.0002	<0.0005	0.0011	<0.0027	<0.003	0.03	0.01	0.003	<0.0057	0.0071
D1																
D2	9.35	<0.0018	0.0155	0.015	0.059	0.054	<0.0002	<0.0005	0.001	<0.0027	<0.003	0.035	0.0242	0.0031	<0.0057	0.0072
TD																
W2	14.8	<0.0018	0.0347	<0.009	0.085	0.052	<0.0002	<0.0005	0.0011	<0.0027	<0.003	0.06	0.0156	0.0036	<0.0057	0.0127
W2																
TD	16.63	<0.0018	<0.0053	<0.009	0.068	0.213	<0.0002	<0.0005	0.0006	<0.0027	<0.003	0.507	0.507	0.0018	<0.0057	0.0111
TD																

Note:
Non-detected values of total ammonia are shown as 1/2 the detection limit to allow calculation of un-ionized ammonia.

Table B-5
Ammonia Concentrations
On Walnut Creek Downstream of RFETS
Spring Through Fall 1994

Date	A-4 Effluent Total Ammonia (mg/L)	A-4 Effluent NH3 (mg/L)	Broomfield Diversion Total Ammonia (mg/L)	Broomfield Diversion NH3 (mg/L)	Old Wadsworth Total Ammonia (mg/L)	Old Wadsworth NH3 (mg/L)
3/25/94	2.999	0.046	2.586	0.013	1.676	0.012
3/27/94	3.521	0.020	2.696	0.012	1.324	0.003
3/29/94	3.594	0.079	2.854	0.005	0.631	0.001
3/31/94	3.801	0.046	3.084	0.029	1.530	0.009
4/2/94	2.234	0.044	2.975	0.007	1.433	0.003
4/4/94	3.898	0.016	3.266	0.013	1.105	0.002
4/6/94	3.849	0.052	3.096	0.024	1.506	0.004
4/8/94	3.436	0.032	2.635	0.005	1.154	0.002
4/10/94	3.230	0.020	2.295	0.024	0.619	0.004
4/12/94	2.550	0.055	1.287	0.243	0.376	0.013
5/15/94			0.030	0.030	0.030	0.030
5/17/94			0.030	0.030	0.030	0.030
5/19/94			0.030	0.030	0.030	0.030
6/19/94	0.474	0.004	0.182	0.002	0.170	0.002
6/21/94	0.510	0.006	0.030	0.002	0.030	0.001
6/23/94	0.583	0.017	0.030	0.007	0.030	0.000
6/25/94	0.619	0.018	0.030	0.016	0.030	0.001
6/27/94	0.085	0.026	0.030	0.017	0.030	0.000
7/24/94	0.003	0.003	0.030	0.014	0.030	0.000
7/26/94	0.003	0.003	0.030	0.022	0.030	0.000
7/28/94	0.003	0.003	0.030	0.018	0.030	0.000
7/30/94	0.109	0.082	0.030	0.019	0.030	0.001
9/8/94	0.003	0.002	0.030	0.014	0.030	0.000
9/10/94	0.003	0.002	0.030	0.030	0.030	0.030
9/12/94	0.003	0.002	0.030	0.030	0.030	0.030
9/14/94	0.003	0.002	0.030	0.024	0.030	0.003
9/16/94	0.003	0.000	0.030	0.013	0.030	0.000